



AK

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : C12N 15/09, 15/11, 15/19 C12N 15/63, C07K 3/18, 3/22 C07K 3/28, 7/06, 7/08 C07K 7/10, 7/40, 15/02 C07K 15/26	A1	(11) International Publication Number: WO 91/00907 (43) International Publication Date: 24 January 1991 (24.01.91)
(21) International Application Number: PCT/US90/03772 (22) International Filing Date: 3 July 1990 (03.07.90) (30) Priority data: 375,739 5 July 1989 (05.07.89) US Not furnished 25 June 1990 (25.06.90) US (71) Applicants: EMORY UNIVERSITY [US/US]; Office of Sponsored Programs, 303 B Dental School, Atlanta, GA 30322 (US). GENELABS INCORPORATED [US/US]; 505 Penobscot Drive, Redwood City, CA 94063 (US). (72) Inventors: LARRICK, James, W. ; Star Route Box 48, Woodside, CA 94062 (US). MORGAN, John, G. ; 1885 California, Mountain View, CA 94040 (US). PEREIRA, Heloise, Ann ; 117 Northern Avenue, #4, Decatur, GA 30030 (US). SPITZNAGEL, John, K. ; 2251 Brianwood Court, Decatur, GA 30033 (US).		(74) Agent: NEEDLE, William, H.; Needle & Rosenberg, Suite 400, 133 Carnegie Way, Atlanta, GA 30303 (US). (81) Designated States: AT (European patent), AU, BE (European patent), CA, CH (European patent), DE (European patent)*, DK, DK (European patent), ES (European patent), FR (European patent), GB (European patent), IT (European patent), JP, KR, LU (European patent), NL (European patent), SE (European patent). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: MONOCYTE CHEMOTACTIC PROTEINS AND RELATED PEPTIDES (57) Abstract <p>Disclosed is a homogeneously pure monocyte chemotactic protein, CAP37, and the entire coding sequences for unprocessed and mature human CAP37 protein. Further, the recombinant production, from nucleic acid coding sequences, of mature CAP37 protein and the mature protein with amino-terminal and/or carboxy-terminal extensions is described. Also disclosed are methods to identify and recombinantly produce bioactive peptides derived from the CAP37 protein coding sequence which are effective chemoattractants of monocytes and/or are capable of binding bacterial lipopolysaccharide. A method of preparing homogeneously pure CAP37 using hydrophobic HPLC is described. Finally, methods of treating wounds and diseased tissue, such as tumors, are described.</p>		

DESIGNATIONS OF "DE"

Until further notice, any designation of "DE" in any international application whose international filing date is prior to October 3, 1990, shall have effect in the territory of the Federal Republic of Germany with the exception of the territory of the former German Democratic Republic.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	ES	Spain	MC	Monaco
AU	Australia	FI	Finland	MG	Madagascar
BB	Barbados	FR	France	ML	Mali
BE	Belgium	GA	Gabon	MR	Mauritania
BF	Burkina Faso	GB	United Kingdom	MW	Malawi
BG	Bulgaria	GR	Greece	NL	Netherlands
BJ	Benin	HU	Hungary	NO	Norway
BR	Brazil	IT	Italy	PL	Poland
CA	Canada	JP	Japan	RO	Romania
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	LI	Liechtenstein	SN	Senegal
CM	Cameroon	LK	Sri Lanka	SU	Soviet Union
DE	Germany	LU	Luxembourg	TD	Chad
DK	Denmark			TC	Togo
				US	United States of America

-1-

MONOCYTE CHEMOTACTIC PROTEINS AND RELATED PEPTIDES**FEDERALLY SPONSORED RESEARCH**

5 Some aspects of this invention were made in the course of Grants AI 17662 and AI 26589 awarded by the National Institutes of Health and, therefore, the Government has rights in some aspects of this invention.

10 CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of pending Application Serial No. 07/375,739, filed July 5, 1989.

FIELD OF THE INVENTION

15 The present invention relates to methods of making and using a 37,000 dalton cationic granule protein normally synthesized by human polymorphonuclear leukocytes.

REFERENCES

- 20 Ausubel, F. M., et al., Current Protocols in Molecular Biology, John Wiley and Sons, Inc., Media PA.
Benfey, P. N., et al., J. Biol. Chem. 262:5377 (1987).
Berman, P. W., et al., Science 222:524 (1983).

- Bing, D. H., et al., Ann. N.Y. Acad. Sci. 485:104 (1984).
Boyum, A., J. Clin. Lab. Invest. 21:SUP97:77 (1968).
Bradford et al., Anal. Biochem. 72: 248-254, 1976.
Brake, A. J., U. S. Patent No. 4,870,008, issued September
5 26, 1989.
Brake, A. J., et al., Proc. Natl. Acad. Sci. USA 81:5330
(1984).
Brown, G. L., et al., Ann. Surg. 208(6):788 (1988).
Cates, K. L., et al., p67 in Leukocyte Chemotaxis, edited by
10 J. I. Gallin and P. G. Quie, Raven Press NY (1978).
Chambers, W. M., et al., Met. Immunol. Immunopathol. 5:197
(1983).
Chang, C. N., et al., Mol. Cell. Biol. 6:1812 (1986).
Chaudhary, V.K., et al., Nature, 335:369 (1988).
15 Chirgwin, J. M., et al., Biochem. 18:5294 (1979).
Chow, C. C., et al., J. Biol. Chem., 265: 8670-8674 (1990).
Collins, E. J., et al., J. Biol. Chem. 265: 8665-8669
(1990).
Cumber, J.A., et al., Methods in Enzymology, 112:207 (1985).
20 Cumming et al., Brit. J. Urology 63: 259-263, 1989.
Duncan, R.J.S., et al., Anal Biochem, 182:68 (1983).
Gershenfeld, H. K., et al., Science 232:854 (1986).
Gillis, S., et al., Behring. Inst. Mitt. 83:1 (1988).
Gluzman, Y., Cell 23:175 (1981).
25 Gray, P. W., et al., Nature 295:503 (1982).
Grunstein, M., et al., Methods in Enzymology 68:379 (1979).
Guarente, L., Methods in Enzymology 101:181 (1983).
Hayashi, H., et al., Int. Rev. Cytol. 89:179 (1984).
Herbert, W. J., in The Handbook of Experimental Immunology,
30 Second Edition, edited by D. M. Weir, Blackwell
Scientific Publications, Oxford, England (1973).
Hopp, T. P., et al., Proc. Natl. Acad. Sci. USA 78:3824
(1981).
Hoylaerts, M., et al., FEBS Lett. 204:83 (1986).

- Hurley, J. V., et al., in Acute Inflammation, second edition, p109, published by Churchill Livingstone, Edinburgh (1983).
- Johnson, D. M. A., et al., FEBS 166:347 (1984).
- 5 Jones, E. W., Ann. Rev. Genetics 18:233 (1984).
- Kawaguchi, T., et al., Am. J. Pathol. 115:307 (1984).
- Kingsman, A. J., et al., U. S. Patent No. 4,615,974, issued October 7, 1986.
- Kopchick, J. J., et al., U. S. Patent No. 4,828,987, issued
10 May 9, 1989.
- Kurjan, J., et al., U. S. Patent No. 4,546,082, issued October 8, 1985.
- Lacy, M. J., et al., J. Immunol. Methods 87:169 (1986).
- Lamb, F.I., et al., Eur J Biochem, 148:265 (1985).
- 15 Lemontt, J. F., et al., DNA 4:419 (1985).
- Lifson, J.D. et al., U.S. Patent No. 4,795,739, issued January 3, 1989.
- Lobe, C. G., et al., Science 232:858 (1986).
- Maniatis, T., et al., Molecular Cloning: A Laboratory
20 Manual, Cold Spring Harbor Laboratories, Cold Spring Harbor NY (1982).
- Martinez-Piteiro et al., Eur. Urol. 15: 146-149, 1988.
- Maruyama, T., et al., Nucleic Acids Res. 14(s) r151-r197.
- McGrogan, M., et al., Biotech. 6:172 (1988 A).
- 25 McGrogan, M., et al., J. Exp. Med. 168:2295 (1988 B).
- McIvor, R. S., et al., Mol. Cell. Biol. 5:1349 (1985).
- Messing, J., Methods in Enzymology 101:20 (1983).
- Miller, J. H., Experiments in Molecular Genetics, Cold Spring Harbor Laboratories, Cold Spring Harbor NY
30 (1972).
- Moriarty, A. M., et al., U. S. Patent No. 4,777,240, issued October 11, 1988.
- Mullis, K., U. S. Patent No. 4,683,202, issued July 28, 1987.
- 35 Nieman, M. A., et al., Biochem. 23:2482 (1984).

- Oeda, K., et al., U. S. Patent No. 4,766,068, issued August 23, 1988.
- Okano, K., et al., J. Biochem. 102:13 (1987).
- Okayama, H., et al., Mol. Cell. Biol 2:161 (1982).
- 5 Olnes, S., Nature, 328:474 (1987).
- Olnes, S., et al., in Molecular Action of Toxins and Viruses, (Elsevier, 1982), Chapter 3.
- Olnes, S., et al., "Toxic Lectins and Related Proteins", in Cohen, P. et al. (eds.), Molecular Action of Toxins and
- 10 Viruses, Elsevier Biomedical Press, 1982, pp. 55-105.
- Patzner, E. J., et al., J. Virol. 58:884 (1986).
- Pereira, H. A., et al., J. Immunol. Methods 117:115 (1989).
- Regelson et al., Clin. Sci. Rev. for (1): 29-42, 1986.
- Revel, M., et al., U. S. Patent No. 4,889,803, issued
- 15 December 26, 1989.
- Salvesen, G., et al., Biochem. 26:2289 (1987).
- Scharf, S. J., et al., Science 233:1076 (1986).
- Scholtissek, S., et al., Gene 62(1):55 (1988).
- Seed, B., Proc. Natl. Acad. Sci. USA 84:8573 (1987).
- 20 Shafer, W. M., et al., Infect. Immun. 45:29 (1984).
- Shafer, W. M., et al., Infect. Immun. 53:651 (1986).
- Sinha, S., et al., Proc. Natl. Acad. Sci. USA 84:2228 (1987).
- Simonsen, C. C., et al., Proc. Natl. Acad. Sci. USA 80:2495
- 25 (1983).
- Smith, D. B., et al., Gene 67(1):31 (1988).
- Snyderman, R., et al., p73 in Leukocyte Chemotaxis, edited by J. I. Gallin and P. G. Quie, Raven Press NY (1978).
- Spitznagel, J. K., et al., J. Immunol. 139:1291 (1987).
- 30 Thim, L., et al., FEBS Lett. 212:2, 307 (1987).
- Ullmann, A., Gene 29(1-2):27 (1984).
- Urlaub, G., et al., Proc. Natl. Acad. Sci. USA 77:4216 (1980).
- Warren, H. S., et al., pages 341-348 in Detection of
- 35 Bacterial Endotoxins with the Limulus Amebocyte Lysate Test, published by Alan R. Liss, Inc. (1987).

- West, G. III, et al., U. S. Patent No. 4,781,871, issued November 1, 1988.
- Wilkinson, P. C., et al., in Acute Inflammation, second edition, p119, published by Churchill Livingstone, Edinburgh (1983).
- Woo, S. L. C., Methods in Enzymology 68:389 (1979).
- Wood, W. I., et al., Nature 312:330 (1984).
- Woodbury, R. G., et al., Biochem. 17:811 (1978).
- Wright, D. G., et al., J. Immunol. 119:1068 (1977).
- 10 Zigmond, S., et al., J. Exp. Med. 137:387 (1973).
- Zsebo, K. M., et al., J. Biol. Chem. 261:5858 (1986).

BACKGROUND OF THE INVENTION

In the process of inflammation an initial wave of inflammatory cells, comprised primarily of polymorphonuclear leukocytes (PMN) is soon followed by a second wave of cells, which are predominantly monocytes (Hurley et al.; Wilkinson et al.). Although it is widely held that monocytes arrive at an area of inflammation as a result of chemotaxis (Hayashi et al.), the specific mediator(s) responsible for the recruitment of monocytes has remained unresolved.

Monocytes are derived from pro-monocytes, found in bone marrow. The pro-monocytes differentiate into monocytes which are released into the blood. The monocytes circulate in the blood until they are attracted to the site of injury by the inflammation process. Once monocytes enter into tissue they mature into macrophages, also referred to as mononuclear phagocytes. Macrophages are able to engulf and destroy foreign antigens; accordingly, macrophages play an important role in the body's immunological defense system. The term "monocyte" as used herein and in the claims refers collectively to both circulating monocytes and to macrophages present in tissue.

The preferential migration of monocytes during the latter phase of inflammation indicates the requirement for highly cell-specific chemoattractant, which has little or no

effect on the migration of PMNs. Experiments indicate that a granule-associated cationic protein (mol. wt. 37,000 daltons) from human PMN acts as a monocyte-specific chemoattractant. This protein has been previously referred to in the literature as CAP37, cationic antimicrobial protein of mol. wt. 37,000 daltons. CAP37 protein has been previously shown to (i) bind bacterial lipopolysaccharides with a high degree of specificity and affinity, and (ii) possess antimicrobial activity against a number of Gram negative bacteria (Shafer et al., 1986).

The instant specification discloses a conventional method for purifying CAP37 to homogeneity and a method for making CAP37 using recombinant DNA techniques. The characterization of the cDNA encoding human CAP37 protein is disclosed. The instant specification also discloses proteins and peptides related and/or derived from CAP37 and also having monocyte chemotactic activity. Recombinant DNA techniques for making the proteins and peptides are also disclosed. Finally, the instant specification discloses methods for treating diseases and wounds using CAP37 and its related proteins and peptides.

SUMMARY OF THE INVENTION

One object of the present invention is to provide a recombinant DNA molecule encoding a cationic granule protein having the following sequence:

Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
30 Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
35 Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly

Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
5 Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro.

The protein of the present invention is a potent chemoattractant for monocytes and is capable of binding bacterial lipopolysaccharide.

10 The invention further includes DNA molecules encoding amino terminal extensions of the protein such as, (a) Met Thr Arg Leu Thr Val Leu Ala Leu Leu Ala Gly Leu Leu Ala Ser Ser Arg Ala Gly Ser Ser Pro Leu Leu Asp, and (b) Met. The invention also includes DNA molecules encoding carboxy
15 terminal extensions such as Gly Pro Ala.

Another important object of the present invention is to provide a recombinant method of producing the cationic granule proteins encoded by the above described sequences. These proteins include the above described amino terminal
20 extensions as well as other modifications, such as the attachment, to the amino or the carboxy terminus of the sequence, of a second protein coding sequence. One example of such a second protein coding sequence is the ricin A chain. Other examples include abrin A chain and
25 trichosanthin. One method of recombinant production is the expression of the cationic granule protein coding sequence fused to the glutathione-S-transferase protein (Sj26) with an in-frame thrombin cleavage site separating the two coding sequences. The fusion protein is then isolated by affinity
30 chromatography for the Sj26 protein portion of the fusion protein, and the cationic granule protein is liberated from the fusion protein by digestion of the fusion protein with the thrombin proteinase.

A further object of the present invention is to provide
35 bioactive peptides having at least 5 amino acids derived from the above described sequence. These bioactive peptides

are either chemotactic for monocytes and/or able to bind bacterial lipopolysaccharide. The present invention further provides a recombinant process for the production of the bioactive peptides.

5 Another object of the present invention is to provide expression vectors containing DNA sequences encoding any of the above protein sequences. These vectors are useful for introducing the coding sequences into suitable hosts. The expression vectors are effective to express the recombinant
10 proteins in a variety of hosts, for example, bacteria, yeast, and mammalian cells. One vector useful for expression of the above described cationic granule protein contains a cytomegalo virus promoter and a polyadenylation signal from SV40, in addition to the dihydrofolate reductase
15 gene to facilitate selection of the vector in the transformed host.

The invention further includes a method of treating a wound by the application of a topical medication containing a cationic granule protein, having the above described
20 sequence, in the medication in a pharmacologically effective amount to promote wound healing. Other additions to the medication may be desirable such as the inclusion of epidermal growth factor also present in a pharmacologically effective amount to promote wound healing. The topical
25 medication may take any number of standard forms such as pastes, gels, creams, and ointments. Additionally, the invention includes methods of treating tumors and other diseases using CAP37 and its related proteins and peptides.

The invention also includes hybrid proteins containing
30 the cationic granule protein, having the above described sequence, covalently attached to a second protein molecule, such as an antibody, ricin A chain, abrin A chain or trichosanthin.

These and other features of the invention will become more fully apparent when the following detailed description of the invention is read in conjunction with the accompanying examples.

5

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a plot of the data which demonstrates the chemotactic properties of the CAP37 protein.

Fig. 2 illustrates the pcDNAI cloning vector used for
10 subcloning inserts from original lambda clones.

Fig. 3 shows a hydropathy index computation for the entire coding sequence of the CAP37 protein including: the amino-terminal extension and the sequence encoding the mature protein.

15 Fig. 4 illustrates the expression vectors used for expression of CAP37 protein in mammalian cells.

Fig. 5 depicts the elution profile of the eluates from the hydrophobic HPLC of the impure product obtained after separation on a SEPHADEX G-75 chromatographic column.

20 Table 1 shows the sequences of peptide fragments derived from the mature CAP37 protein as relevant to the Examples.

Table 2 shows a comparison of N-terminal amino acid sequence of CAP37 protein with several inflammatory cell
25 proteases.

Table 3 shows the nucleic acid and protein sequences of the first isolated cDNA insert having homology to CAP37 protein.

Table 4 shows the nucleic acid and protein sequences of
30 the 6a.1 clone insert.

Table 5 shows the amino acid sequences for three (3) CAP37 peptide fragments which do not share homology with elastase or cathepsin G.

Table 6 illustrates the effect of peptide No. 1 on
35 monocyte chemotaxis.

Table 7 illustrates the effect of peptide No. 3 on monocyte chemotaxis.

DETAILED DESCRIPTION OF THE INVENTION

5 I. Purification and Characterization of the Human CAP37 Protein

A. Purification and Sequencing of CAP37 Protein.

CAP37 protein was purified from polymorphonuclear leukocytes (PMN) obtained from healthy adult donors (Example
10 1-A). The crude preparation generated from PMNs was dialyzed and applied to an ion exchange column. The eluent containing the CAP37 protein came off of the column at NaCl concentrations in the range of 0.6 to 0.7 M, as judged by SDS-PAGE of the fractions. This eluent was dialyzed and
15 concentrated. The concentrated preparation was size fractionated and the fractions analyzed by SDS-PAGE to determine the fractions containing the CAP37 protein (Example 1).

Ascites fluid containing antibodies against CAP37
20 protein was prepared by injecting mice with alum-adsorbed CAP37 protein emulsified in Freund's complete and Freund's incomplete adjuvant (Example 1-C). The specificity of the ascites fluid reactivity against the CAP37 protein was demonstrated in ELISA assays using CAP37, CAP57 (a cationic
25 antimicrobial protein of mol. wt. 57,000 Da; Spitznagel et al.), lactoferrin, myeloperoxidase, cathepsin G and lysozyme as the antigens.

Immunocytochemical analysis of normal human PMN using the monospecific polyvalent mouse antiserum to CAP37 established that CAP37 was a component of the cytoplasmic granules of human PMNs. All other peripheral blood cells which included eosinophils, monocytes, lymphocytes and red blood cells, did not stain positive for CAP37.

Immunocytochemical analysis also demonstrated the presence of CAP37 in normal bone marrow, in cells belonging to the myeloid lineage, and in peripheral blood PMN from patients with chronic myelogenous leukemia (CML).

For chemotactic assays the CAP37 protein was further purified by fractionation of the preparation using hydrophobic high performance liquid chromatography (HPLC). For amino acid sequence determination a final desalting step was added utilizing reverse-phase HPLC (Example 1).

The N-terminal amino acid sequence of the CAP37 protein was determined by standard microsequencing procedures (Example 1-D). Table 1 (Example 1) shows the peptide fragment sequences which were determined for part of the mature CAP37 protein. The first 42 amino acids at the amino terminus of CAP37 have received accession number A33070 from the Biomedical Research Foundation, Georgetown University Medical Center, Washington, D.C. 20007.

B. Chemotactic Properties of CAP37 Protein

Chemotaxis assays were performed using the modified Boyden chamber technique (Example 2). The results (Fig. 1) demonstrated that CAP37 was obviously chemotactic for human
5 monocytes in the range of 10 to 10,000 pM. CAP37 appeared to be as effective as FMLP in attracting monocytes. These experiments suggest CAP37 did not have any effect on PMN and lymphocyte chemotaxis.

In addition to the observed chemotactic effect on human
10 monocytes, CAP37 at a higher concentration of 1000 ng/ml (2.7×10^{-8} M) was chemotactic for rabbit monocytes as well. This may reflect either (i) a reduction in the numbers of receptors for CAP37 on rabbit monocytes as compared to the number of receptors on human monocytes, or,
15 (ii) a difference in the K_d values for the two species. The effect was selective for monocytes since, rabbit PMN did not show a chemotactic response towards CAP37.

One of the important aspects of identification of a chemotaxin is to distinguish directed cell movement
20 (chemotaxis) through the filters as opposed to merely accelerated random motion (chemokinesis). Using the checkerboard assay (Example 2) it was demonstrated that, in addition to its chemotactic properties, CAP37 protein also has some chemokinetic effect on monocytes.

C. Protein Sequence Comparisons with the Amino Terminus of the CAP37 Protein.

Using the amino terminal sequence of the CAP37 protein, a homology search was conducted of known protein sequences.

5 This search revealed substantial homologies with the amino termini of a subset of serine proteases which mediate a number of functions involved in the inflammatory response (Table 2).

Most of the serine proteases with which CAP37 protein
10 shares its greatest homology (elastase, cathepsin G, rat mast cell proteases I and II, H Factor and cytotoxic T cell specific protein I) are derived from the granules of peripheral blood cells. Further, these homologous proteins are known to play important roles in inflammation, such as
15 cytolysis or degradation of extracellular matrices.

Two other serine proteases, bovine thrombin (Bing et al.) and a trypsin-like protease in guinea pig plasma (Kawaguchi et al.), have been described which exhibit chemotactic activity. Further, Wright et al. have described
20 the presence of a factor(s) in PMN specific granules which acts on serum to produce chemotactically active C5a and the opsonin C3b.

The experiments performed in support of the present invention show the isolation, characterization and
25 purification to homogeneity of a PMN-granule associated protein which has monocyte specific chemotactic activity.

Further, the CAP37 protein is capable of bactericidal activity and thus may perform two very important functional roles in vivo.

5 II. Cloning of the CAP37 Protein Coding Sequence:
Isolation of a First cDNA Having Homology to
CAP37 Protein.

For the isolation of the CAP37 cDNA coding sequence, poly-A+ RNA was isolated from tumor cell line HL60 (Example
10 4-A,B). Using the CAP37 protein specific antibodies generated in Example 1 the HL60 cell line was shown to contain antigens which reacted with this antibody. Double-stranded (ds) cDNA was generated from the isolated RNA molecules (Example 4-C,D). These ds molecules were cloned
15 into the vector lambda-gt10 (Example 4-E).

Plaques resulting from recombinant phage were transferred to duplicate filters and the filters hybridized with two CAP37 sequence specific probes (Example 4-E). The probes were non-coding strand 20-mer degenerative sets
20 generated from the known amino terminal protein sequence of CAP37 protein (Table 1, Example 1) based on the use of preferred human codons (Maruyama et al.). The filters were then probed with each probe set. The duplicate filters showed one recombinant plaque that was convincingly positive
25 with both probes.

The phage was purified from the plaque which tested positive and the double-stranded cDNA insert was isolated from the phage. This insert was then cloned into vector

pcDNAI (Example 5, Fig. 2) and the insert sequenced. The complete sequence of this first cDNA clone is shown in Table 3.

The nucleic acid sequence of the cDNA was translated
5 into the corresponding protein sequences in all three
frames. One of the reading frames showed significant
alignment to the CAP37 protein sequence with the following
exceptions: (i) the cloned sequences indicate that the
encoded protein most likely has a precursor form since the
10 cloned sequences contain an additional 48 amino acids 5' to
and in frame with the open reading corresponding to the
CAP37 protein sequence (Example 6); (ii) there appeared to
be some carboxy terminal differences in protein sequence;
and, (iii) 19 amino acids present in a CAP37 protein
15 fragment amino acid sequence were not found in the nucleic
acid insert sequence (Example 6). The 19 amino acids
missing from the protein encoded by the first cDNA clone
suggested that although this clone contained coding
sequences for the majority of the CAP37 protein it was not
20 the correct cDNA.

Hybridization of other CAP37 specific probes to the
above filters did not result in the identification of any
more likely candidate plaques.

In order to clone a cDNA encoding the complete CAP37
25 protein sequence the following strategy was employed. A
specific DNA fragment, which would span the region where the
discrepancy between the cDNA sequence and the protein

sequence was observed (Example 6), was amplified (Example 7). One end of this DNA fragment was chosen to correspond to the amino acid sequence CQVAGWG (underlined in the CAP37 peptide sequence presented in Example 6): a degenerate 20-mer oligonucleotide probe (designated Intrlc) was designed to correspond to these amino acids.

The second end of the above discussed DNA fragment was less stringently designated. A number of non-degenerate 20-mer primers were designed from the sequence of the non-coding strand of CAP37 first cDNA which was 3' to the end of the site where the nucleic acid sequence diverged from the protein coding sequence (see * in the CAP37 first cDNA sequence in Example 6).

Total human genomic DNA was used as template in DNA amplification reactions utilizing the above described primers (Example 7). The products of the amplification reactions were split into two samples, fractionated on an agarose gel and then one-half of the gel containing a complete set of samples was transferred to a nitrocellulose filter. The filter was then probed with the radioactively-labeled CAP37 first cDNA: one positive band was detected. The DNA was extracted from the region of the second half of the agarose gel corresponding to the positive band. This DNA fragment (Intrlc/669nc) was then sequenced (Example 7-A).

A 50-mer probe corresponding to a region of the Intrlc/669nc sequence which was not present in the CAP37 first cDNA clone was synthesized. This probe was then used to screen 200,000 plaques generated from the lambda-HL60 cDNA library (Example 7-B). After a secondary screen 5 plaques remained clearly positive. One of these clones, designated 6a.1, was sequenced using dideoxy sequencing. The complete DNA sequence of the 6a.1 clone is illustrated in Table 4.

10 The DNA sequence corresponding to clone 6a.1 was translated in all three reading frames. One reading frame aligned with the amino acid sequences of the CAP37 peptide fragments determined in Example 1. The CAP37 mature protein coding sequence was preceded, in frame, by 26 amino acids, 15 and had a short carboxy terminal extension. These results indicate that the 6a.1 clone is a complete cDNA clone encoding the CAP37 protein.

 The first approximately 20 amino acids of the cDNA encoded CAP37 protein have a high degree of hydrophobicity 20 (Fig. 3). This sequence has the length and hydrophobicity of a typical eucaryotic secretory signal sequence (Example 8). The remaining amino acids in this 26 amino acid sequence and/or the carboxy-terminal extension may be involved in further cellular processing of the CAP37 protein 25 or they may represent an inactive precursor form of the protein.

The portion of the open reading frame corresponding to the mature form of the CAP37 protein has an estimated molecular weight of 24,276 kilodaltons. Previously Shafer et al. (1986) determined the molecular weight of the CAP37 protein to be approximately 37,000 daltons. This discrepancy is most likely the result of post-translational modification, e.g. glycosylation, of the CAP37 protein.

Subsequent to the isolation and sequencing of the 6a.1 cDNA insert, the complete protein sequence of the mature CAP37 protein was determined. With the exception of the above described amino and carboxy terminal extensions, the coding sequence of the mature CAP37 protein exactly aligns with the protein sequence encoded by the 6a.1 insert.

15 III. Recombinant Expression of the CAP37 Protein

Factors that are involved in successful expression of a cloned gene in a particular system include, solubility within the cell, non-toxicity to the cell, possible secretion by the expressing cell, low levels of proteolytic digestion by the cell and ease of purification in the system. Folding, disulfide bond formation, as well as post-translational modifications (glycosylation, phosphorylation, etc.) can affect expression and synthesis of proteins; these factors differ according to the host cells used for expression.

The E. coli plasmid system to express CAP37 was described by Smith et al. This system involves the use of a plasmid expression vector designed to direct synthesis of foreign polypeptides as fusions with the protein Sj26; Sj26
5 is a glutathione S-transferase protein from Schistosoma japonicum. Purification of the fusion protein is accomplished by affinity chromatography on immobilized glutathione. Smith et al. have described the use of expression vectors encoding a thrombin cleavage site
10 immediately adjacent the carboxy terminus of Sj26 and the amino-terminal of the foreign protein which is to be expressed. Recovery of the foreign protein can be achieved by thrombin digestion of the purified fusion protein (Example 9-A). The thrombin digestion is followed by a
15 final purification step to remove Sj26. High yields of several soluble proteins have been demonstrated with these plasmids.

Alternatively, the thrombin cleavage site can be replaced by another protease cleavage site such as
20 collagenase (EC 3.4.24.3, from Clostridium histolyticum) by insertion of an oligonucleotide linker containing the appropriate cleavage sequence (e.g., see Example 10-B).

In addition to the above described vector there are numerous E. coli expression vectors known to one of ordinary
25 skill in the art useful for the expression of CAP37 protein. If necessary an amino terminal methionine can be provided the CAP37 protein coding sequence by insertion of a Met

codon 5' and in-frame with the CAP37 protein coding sequence. Also, the carboxy-terminal extension of the cDNA encoded CAP37 protein can be removed using standard oligonucleotide mutagenesis procedures.

5 There are several advantages to yeast expression systems. First, evidence exists that proteins produced in a yeast secretion systems exhibit correct disulfide pairing (Zsebo et al.). Second, post-translational glycosylation is efficiently carried out by yeast secretory systems (Gillis
10 et al.; Thim et al.; Chang et al.; Hoylaerts et al.; Lemontt et al).

 The Saccharomyces cerevisiae pre-pro-alpha-factor leader region (encoded by the MF α -1 gene) is routinely used to direct protein secretion from yeast (Brake et al., 1984).
15 The leader region of pre-pro-alpha-factor contains a signal peptide and a pro-segment which includes a recognition sequence for a yeast protease encoded by the KEX2 gene: this enzyme cleaves the precursor protein on the carboxyl side of a Lys-Arg dipeptide cleavage-signal sequence. The
20 CAP37 protein coding sequence is fused in-frame to the pre-pro-alpha-factor leader region (Example 9-B). This construct is then put under the control of a strong transcription promoter, such as the alcohol dehydrogenase I promoter or a glycolytic promoter. The CAP37 protein coding
25 sequence is followed by a translation termination codon which is followed by transcription termination signals. Alternatively, the CAP37 protein coding sequences can be

fused to a second protein coding sequence, such as Sj26 (Example 9-A) or α -galactosidase (Example 10-B), used to facilitate purification of the fusion protein by affinity chromatography. The insertion of protease cleavage sites to
5 separate the components of the fusion protein, such as described above for CAP37 protein expression in E. coli, is also applicable to constructs used for expression in yeast.

Mammalian cells permit the expression of proteins in an environment that favors important post-translational
10 modifications such as folding and cysteine pairing, addition of complex carbohydrate structures, and secretion of active protein.

Vectors useful for the expression of CAP37 protein in mammalian cells are shown in Fig. 4. These vectors are
15 characterized by insertion of the CAP37 protein coding sequence between a strong viral promoter and a polyadenylation signal. The vectors further contain genes conferring either Genetimidin or methotrexate resistance for use as selectable markers. The CAP37 protein coding
20 sequence has been introduced into a Chinese hamster ovary cell line using a methotrexate resistance-encoding vector (Example 9-C). Presence of the vector DNA in transformed cells has been confirmed by Southern analysis and production of an RNA corresponding to the CAP37 protein coding sequence
25 has been confirmed by Northern analysis.

Alternative vectors for the expression of CAP37 in mammalian cells, are those similar to those developed for the expression of human gamma-interferon, tissue plasminogen activator, clotting Factor VIII, hepatitis B virus surface antigen, protease Nexin1, and eosinophil major basic protein, will be employed (Gray et al; Wood et al.; Patzer et al.; Berman et al.; McGrogan et al, 1988 A and B). Further, the vector shown in Fig. 2 contains CMV promoter sequences and a polyadenylation signal available for expression of inserted DNAs in mammalian cells (such as COS7).

The identification and use in cloning of the entire CAP37 protein coding sequenced identified by cDNA sequencing is particularly useful in mammalian cells since the putative pre-pro sequence (i.e. the first 26 amino acids of the cDNA encoded protein coding sequence) may have important effects on secretion and other protein processing events.

IV. Bioactive Peptide Fragments of the CAP37 Protein

A bioactive portion of the CAP37 protein is defined as a peptide fragment of at least about 5 amino acids derived from the CAP37 protein coding sequence (Table 4) which has chemotactic or lipopolysaccharide-binding properties (Example 11).

One method of identifying bioactive fragments of CAP37 is described in Example 12. Of the three fragments identified and synthesized, two were active. Another method

of identifying bioactive fragments is described in Examples 10 and 11. In this latter method the CAP37 protein coding sequence is fragmented by digestion with DNase I (Example 10-A). The CAP37 protein coding sequence could also be
5 fragmented using specific restriction endonucleases, such as HaeIII which has 19 cut sites in the coding sequence. These fragments are then ligated into a vector which allows identification of in-frame fusions by a simple plate assay (Example 10-B). The presence of CAP37 protein coding DNA
10 sequences can be verified in the clones utilizing colony hybridization. The in-frame fusions represent candidate CAP37 peptides which can be assayed for their chemotactic and lipopolysaccharide binding properties as described in Example 11.

15 Glycosylation and other post-translational modifications may not be required to detect these activities, thus expression of these peptides in E. coli is the method of choice. However, the fusions of the bioactive peptides to α -galactosidase can also be expressed in yeast
20 or mammalian cells essentially as described above and in Example 9.

V. Anti-CAP37 Antibodies

In another aspect, the invention includes an antibody
25 which is specific against CAP37 protein or bioactive peptide derivatives thereof, or specific against CAP37 protein/peptide fusion proteins (Examples 9-A, 10, and 11).

To prepare antibodies, a host animal, such as a rabbit, is immunized with the purified CAP37 protein/peptide antigen. The host serum or plasma is collected following an appropriate time interval, and this serum is tested for antibodies specific against the CAP37 protein antigen. Example 12 describes the production of rabbit serum antibodies which are specific against the CAP37 protein/peptide.

The gamma globulin fraction or the IgG antibodies of immunized animals can be obtained, for example, by use of saturated ammonium sulfate or DEAE SEPHADEX, or other techniques known to those skilled in the art for producing polyclonal antibodies.

Alternatively, the purified antigen may be used for producing monoclonal antibodies. Here the spleen or lymphocytes from an immunized animal are removed and immortalized or used to prepare hybridomas by methods known to those skilled in the art.

Antibodies secreted by the immortalized cells are screened to determine the clones that secrete antibodies of the desired specificity (Example 12), for example, using the Western blot method (Ausubel et al.).

VI. Hybrid Proteins Created with CAP37 Protein

In another aspect, the invention includes CAP37 fused at its amino or carboxy end with a second protein or peptide to form a hybrid protein. The CAP37 protein making up the

hybrid protein is preferably recombinantly produced CAP37 protein or a bioactive portion thereof, as described above.

The hybrid CAP37 protein or bioactive peptide (CAP37 protein/peptide) may be formed by chemical conjugation or by
5 recombinant techniques. In the former method, the second peptide and CAP37 protein/peptide are modified by conventional coupling agents for covalent attachment (Duncan; Cumber).

Where CAP37 protein/bioactive peptide is used in tumor
10 therapy, the protein/peptide may be advantageously fused with a polyclonal or monoclonal antibody specifically directed against target tumor-specific cell surface antigen(s). This fusion protein is then infused at or near the tumor site to attract monocytes to the site.

15 As an alternative chemical conjugation method, CAP37 protein/peptides not containing cysteine may be prepared to contain cysteine to allow disulfide coupling of the CAP37 protein to an activated second protein, thus simplifying the coupling reaction. The expression vector used for
20 production of recombinant CAP37 bioactive peptide can be modified for insertion of an internal or a terminal cysteine codon according to standard methods of site-directed mutagenesis or oligonucleotide linker insertion.

In a preferred method, the hybrid protein is prepared
25 recombinantly using an expression vector in which the coding sequence of the fusion peptide is joined to the CAP37 protein/bioactive peptide coding sequence. For example, an

expression vector formed is designed to contain the following components: (a) a synthetic trp/lac promoter positioned appropriately ahead of a ribosome binding site that is also positioned appropriately ahead of an ATG start codon which is 5' to an cloning site; (b) the ricin A chain coding sequence (Olmes; Olmes et al.; Lamb et al.); (c) a spacer encoding sequence coding for 10 proline residues, which spaces the ricin A chain and CAP37 protein/peptide moieties; (d) the coding sequence for the CAP37 protein/peptide; and, (e) a stop codon positioned adjacent the carboxy-terminal codon of CAP37 protein/peptide. The method generally follows that used in fusing a soluble CD4 to domains 2 and 3 of pseudomonas exotoxin A, as described previously (Chaudhary).

The expression vector containing the fusion protein coding sequences is analyzed for expression of the hybrid protein. Briefly, the expression vector is cultured in a suitable bacterial host under IPTG induction conditions to a desired cell density. The cells are harvested, ruptured by sonication, and the cell material is clarified by centrifugation. The clarified material is tested for (a) chemotactic ability, to confirm CAP37 protein/bioactive peptide activity, and (b) for ribosome inhibition activity, to confirm the ricin A chain enzymatic activity.

The protein may be purified by molecular-sieve and ion-exchange chromatography methods, with additional

purification by polyacrylamide gel electrophoretic separation and/or HPLC chromatography, if necessary.

The ricin/CAP37 fusion protein can be used as a very specific anti-tumor reagent for cancers of monocyte cells.

- 5 It will be appreciated from the above how other second protein-CAP37 protein/peptide fusion proteins may be prepared. One variation on the above fusion is to exchange positions of the ricin A chain and CAP37 protein/peptide coding sequences in the fusion protein expression vector.
- 10 Other variations would use abrin A chain or trichosanthin rather than ricin A chain. (Olnes et al., 1982; Lifson et al., 1989; Chow et al., 1990; Collins et al., 1990).

VII. Utility

- 15 The cloning and expression of human CAP37 protein provides an important source of the purified protein -- simplifying preparation and allowing production of large quantities of the protein.

- 20 The purified CAP37 protein, or a bioactive peptide thereof, can be applied to wound sites resulting in a two-fold benefit: (i) the protein is a strong anti-microbial agent (Shafer et al., 1986), and (ii) monocytes are attracted to the wound site. The CAP37 protein can be applied at a wound site by infusion, allowing the protein to
- 25 form a gradient in surrounding tissue by diffusion. Alternatively, the CAP37 protein/peptide can be formulated in a topical medication, such as pastes, gels, creams, and

ointments, by standard methods (e.g., West et al.). The topical medication is then applied at the wound site: this method of application allows a controlled release of the protein at the wound site. Such topical formulations may
5 also contain other components, such as antibiotics or epidermal growth factor (Brown et al.), to facilitate healing.

The purified CAP37 protein, or a bioactive peptide thereof, may also be used in treating other diseases such as
10 cancers. CAP37 can be administered through systemic injection, intravesical administration or may be injected locally into an accessible tumor mass. The route of administration would depend on the nature and size of the tumor or other diseased tissue being treated. CAP37, or a
15 bioactive peptide thereof, could be administered using protocols for adjuvant immunotherapy currently using bacterial vaccines such as Bacille Calmette-Guerin (BCG) or Corynebacterium parvum. Such protocols are well known in the art. (Regelson et al., 1986;; Martinez-Piñeiro et al.,
20 1988; Cumming et al., 1989).

Essentially, an effective amount of CAP37 would be mixed with a suitable solvent or carrier and administered to an animal by one of the routes of administration established for other adjuvants such as BCG. CAP37 could be
25 encapsulated in multilamellar phospholipid vesicles, or other encapsulating material, to aid in administration. Depending on the area to be treated, the route of

administration and the dose, CAP37 might be administered without a carrier.

An effective dose of CAP37 would vary depending upon the route of administration and the area to be treated.

- 5 CAP37 could be administered systemically or intraperitoneally in a dose of 100 ng/kg.

Because of its ability specifically to attract monocytes, CAP37 could be used to treat any disease involving monocyte localization. These diseases would
10 include neoplastic diseases, rheumatoid arthritis, hepatitis, chronic obstructive pulmonary disease, chronic periodontal disease, parasitic diseases such as malaria, tuberculosis and leprosy. CAP37 could also be used to treat diseases involving defects of monocyte chemotaxis such as
15 Wiscott Aldrich syndrome, chronic mucocutaneous candidiasis, chronic granulomatous disease, Chediak Higashi syndrome, systemic lupus erythematosus and herpes simplex.

Since the CAP37 protein binds bacterial lipopolysaccharide, CAP37 protein, or a bioactive peptide
20 thereof, may also provide an effective treatment for endotoxemia. A solution of the CAP37 protein may be parenterally applied to a patient to bind endotoxins that are circulating in blood and facilitate their clearing.

Further, as discussed above (Section VI), hybrid
25 proteins containing CAP37 protein, or bioactive portions thereof, may be useful in tumor therapies, particularly tumors of monocytes.

The following examples illustrate, but are in no way intended to limit the present invention.

Example 1

5 Purification and sequencing of human CAP37 protein

A. Source and Preparation of Peripheral Blood PMN and Monocytes

Blood was collected into sterile sodium-EDTA tubes by venepuncture from healthy adult donors. The

10 polymorphonuclear leukocytes (PMN) were separated from mononuclear cells essentially by the ficoll hypaque density gradient technique of Boyum, followed by dextran sedimentation (T500, Pharmacia 3% in saline) and hypotonic lysis of contaminating red blood cells (RBC).

15 The mononuclear cell band was further purified to separate the monocytes from the lymphocytes. The mononuclear cells were washed once in phosphate buffered saline (PBS: 0.01 M Na_2HPO_4 , containing 0.15 M NaCl, pH 7.4) and resuspended in PBS to a total volume of 5.1 ml. This

20 cell suspension was then added to 6.7 ml of SEPRACELL-MN reagent (a colloidal, silica-based medium having a density of 1.099 g/ml, and available from Sepratech Corporation, Oklahoma City, Oklahoma), and centrifuged (1500 g for 20 min at 22°C). The cells were washed twice in PBS (150 X g, 15

25 min) and resuspended in Geys buffered saline (Gibco) containing 2% bovine serum albumin (BSA - Fraction V, endotoxin free, Boehringer Mannheim Biochemicals) at a final

concentration of 2×10^6 cells/ml. (Geys buffer has the following composition: $\text{CaCl}_2(\text{anhyd.})$ 0.17 g/L; KCl 0.37 g/L; KH_2PO_4 0.03 g/L; $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ 0.21 g/L; $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ 0.07 g/L; NaCl 7 g/L; NaHCO_3 2.27 g/L; $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$ 0.226 g/L; 5 D-Glucose 1.00 g/L.) The monocytes were greater than 95% pure as determined by Wright's and non-specific esterase staining.

Peripheral blood mononuclear cells from adult female rabbits, were separated on a 61% PERCOLL (Pharmacia) 10 gradient (Chambers et al.). This technique separated the mononuclear cells from the RBC and PMNs. No further separation of monocytes from lymphocytes was undertaken with the rabbit blood.

15 B. Purification of CAP37

A granulocyte concentrate (>95% PMN) was obtained by leukophoresis from a normal human donor. The PMN were disrupted by homogenization in a Potter-Elvehjem tissue grinder (Kontes) for 60 sec at 4°C. Mixed (specific and 20 azurophil) granules were harvested by differential centrifugation. The supernatant obtained by centrifuging at 126 x g for 15 minutes was further centrifuged at 20,000 x g for 20 minutes to yield a pellet of mixed granules which was extracted at 4°C with 0.2M sodium acetate (pH 4.0). Granule 25 debris was collected by high-speed centrifugation at 20,000 x g for 30 min. The protein concentration was determined by

the method of Bradford with chick egg white lysozyme as the standard. Bradford et al., 1976.

The crude granule extract was dialyzed against 50 mM sodium acetate (pH=5) and 0.15 M NaCl at 4°C overnight. The dialysate was then applied to a carboxymethyl SEPHADEX ion exchange column (a weakly acidic cation exchanger having sodium as a counter-ion and carboxymethyl as a functional group, and available from Pharmacia, Piscataway NJ) which had been equilibrated with 50 mM sodium acetate (pH=5) and 0.15 M NaCl. The column was extensively washed with 6M urea in 0.05M sodium acetate (pH5) containing 1.5M sodium chloride. Protein bound to the column was eluted using a two-step linear salt gradient consisting of 0.15 to 0.4 M and 0.4 to 1.0 M NaCl in 50 mM sodium acetate pH=5. Protein elution was monitored by measuring the absorbance of the eluent at 280 nm. Salt concentrations of the fractions were determined by conductivity measurements. Fractions from the CMS column were tested by ELISA using antiserum to CAP37 to determine those fractions which contained CAP 37.

The positive fractions were pooled and dialyzed overnight against 0.2 M sodium acetate (pH=4) at 4°C, concentrated by membrane ultrafiltration at 4°C using a YM-5 membrane filter (an ultrafiltration membrane having very low non-specific protein binding properties, a nominal molecular weight cut-off of 5000 daltons, a clean water flow rate of 0.07 - 0.1 ml/min/cm² and available from Amicon Corp., Lexington KY). The concentrated preparation was applied to

a SEPHADEX G-75 SF (Pharmacia) column (0.5 by 50 cm) which had been equilibrated with 0.2 M sodium acetate (pH=4). (SEPHADEX G-75 is a chromatographic medium comprised of a bead-formed gel prepared by cross-linking dextran with epichlorohydrin; said medium having a dry bead size of 10-40 μ , bed volume of 12-15 ml/g of dry SEPHADEX, and fractionation range for globular proteins and peptides of 3,000-70,000 daltons.) Fractions were eluted using the equilibration buffer and the A_{210} of each fraction determined. The fractions were analyzed by ELISA and by SDS-PAGE to determine the fraction containing the CAP37 protein.

The CAP37-enriched fraction obtained from the molecular sieve column was further processed using hydrophobic high performance liquid chromatography (HPLC) (BIO-GEL TSK phenyl 5PW column, 7.5 mm x 0.75mm, packed with a 10 micron macroporous support having 1,000 angstrom pores and containing a low density of phenyl groups which promote strong but nondenaturing hydrophobic interactions with proteins, said column available from Biorad Laboratories). The proteins were eluted using a 60 min linear gradient from 1.7 M to 0 M $(\text{NH}_4)_2\text{SO}_4$, which contained 0.1 M sodium phosphate pH 7.0. The recovery was determined by the optical density of the proteins at 210 nm. The fractions obtained from the hydrophobic HPLC column were pooled independently and the $(\text{NH}_4)_2\text{SO}_4$ removed by dialysis

employing a stirred cell concentrator (YM-5 membrane, Amicon) with 0.2 M sodium acetate buffer, pH= 4.0.

The purity of the fractions was determined by SDS-PAGE, western blot analysis and ELISA. All these results confirm
5 that CAP37 prepared in this manner is devoid of other contaminating granule proteins which include the defensins, cathepsin G, myeloperoxidase, lactoferrin, and CAP57, and thus indicates that the outlined method yields a highly purified preparation of CAP37.

10 An important aspect of the production of CAP37 was to keep it free from endotoxin contamination. All reagents and buffers were prepared using pyrogen-free water and tested for endotoxin contamination using the Limulus amoebocyte assay (Whittaker Products). All glassware used was pyrogen-
15 free. The starting material for each column was always checked for endotoxin contamination before it was applied to the column and, most importantly, the final product was always checked for the presence of endotoxin before use.

As seen in Fig. 12, the elution profile from the
20 hydrophobic HPLC column indicated the presence of two proteins. CAP37 was confined to Peak 2, the more hydrophobic peak. Peak 1 was found to contain cathepsin G, as judged by SDS-PAGE.

SDS-PAGE was performed to depict the stages of
25 purification of CAP37 from normal human crude granule extract (CGE). The analysis was performed according to the method described by Laemmli. Nature, 227: 680, 1970. The

samples were solubilized in 0.625M Tris (pH 6.8), 4% (w/v) SDS, and 1% (v/v) beta mercapto ethanol, at 100°C for 5 min and analyzed on a 12.5% gel essentially according to the method of Laemmli. Nature 227: 680, 1970. The analysis was
5 performed under reducing conditions with a 12.5 % separating gel and a 4% stacking gel as described by Laemmli. Nature 227: 680-685, 1970. The ratio of the acrylamide to the bisacrylamide was 37.5. Electrophoresis was carried out until the bromophenol blue dye reached the bottom of the
10 separating gel. The gel was removed and fixed in a 25% isopropanol, 7% acetic acid mixture. The gel was oxidized and stained with silver to visualize the protein bands.

The gel was silver stained according to well established protocols. Lane 1 contained 2 μ g "rainbow"
15 molecular weight markers (Amersham). Lane 2 contained 5 μ g of crude granule extract (CGE). Lane 3 contained 400 ng of peak C material obtained from the G-75 column which served as the starting material for the HPLC column. Lane 4 contained 350 ng of peak 2 (CAP37) from the HPLC column.
20 Lane 5 contained 350 ng of peak 1 from the HPLC column and lane 6 contained purified cathepsin G. The molecular weight standards used included myosin (M_r 200,000), phosphorylase b (M_r 92,500), bovine serum albumin (M_r 69,000), ovalbumin (M_r 46,000), carbonic anhydrase (M_r 30,000), trypsin inhibitor
25 (M_r 21,500) and lysozyme (M_r 14,300).

The CAP37 material from peak 2 (lane 4) migrated in SDS-PAGE as three extremely closely spaced bands with a molecular weight near 37,000 daltons. This electrophoretic behavior probably indicates glycosylation of the protein, rather than any heterogeneity of the protein preparation. Furthermore, the fact that this preparation yielded an unambiguous amino acid sequence would also tend to indicate the absence of heterogeneity.

Judging from the nearly identical migration patterns of peak 1 from the HPLC Column (lane 6) and cathepsin G (lane 5), it may be concluded that this peak 1 material is cathepsin G. This was confirmed by the western blots.

The fractions obtained from the HPLC column were also analyzed by western blots. Western blot analysis was carried out according to the method of Towbin et al. (Proc. Natl. Acad. Sci. USA. 76: 4350-4354, 1979) with some modifications. Following electrophoresis on a 12.5 % SDS-PAGE gel, the proteins were transferred onto a nitrocellulose membrane (Biorad, Richmond, CA) in a TE series, Transphor Electrophoresis Unit (Hoefer Scientific Instruments, CA) under constant current (200 mA) at 11°C for 1.5 hr. The concentration of the methanol in the buffer was reduced from 20% to 5% (v/v) and the pH raised to 9. The protein was detected on the nitrocellulose membrane using a mouse antibody to CAP37 (1: 100 dilution) and an alkaline phosphatase immunoblotting system with the addition of 10 units per ml heparin sulfate buffer (Eastman, Kodak)

(Spitznagel et al., J. Immunology 139: 1291-1296, 1987) in the wash buffer (0.15 M NaCl, 0.01M Tris HCl (pH 7.5), 0.01% v/v TWEEN 20). Color development was obtained with the nitroblue tetrazolium/BCIP system.

5 The results of the western blot confirmed the SDS-PAGE results. Lane 1 contained molecular weight markers as described for the SDS-PAGE. Lanes 2 and 6 contained crude granule extract. Lanes 3 and 7 contained peak C material from the G-75 column. Lanes 4 and 8 contained peak 2 from
10 the HPLC column and lanes 5 and 9 contained peak 1 from the HPLC column. The protein concentrations of all the samples loaded onto the gel were the same as described above.

 Lanes 1 to 5 were probed with goat anti-human cathepsin G (1:2000 dilution) and lanes 6 to 9 were probed with mouse
15 anti-human CAP37 (1: 100 dilution). The second antibody was conjugated to alkaline phosphatase (1: 7500 dilution, Promega). Color development was obtained using the nitroblue tetrazolium/ BCIP system as outlined in the manufacturers handbook (Promega). The goat anti-human
20 cathepsin G antiserum reacted with crude granule extract, peak C material and peak 1 from the HPLC column. It did not react with CAP37 (peak 2 material from the HPLC column). On the other hand, the antiserum to CAP37 reacted with peak 2 material but not with the cathepsin G. This indicates that
25 CAP37 was totally separated from the contaminating cathepsin G in the final step of the purification which is performed on the hydrophobic HPLC column.

The proteins obtained from the HPLC column were further analyzed by ELISA which confirmed the purity of the CAP37 preparation. The ELISA method used is described in Pereira, et al., J. of Immunological Methods 117: 115- 120, 1989, and has proven to be a reproducible and sensitive method for the detection of cationic proteins. Briefly, the protein was attached to a 96 well microtitre plate (NUNC Immunoplate I, VWR Scientific) which was pre-treated with poly-L-lysine. Following an overnight incubation at 4°C, the plate containing the antigen was washed four times in phosphate buffered saline (pH 7.4). Non-specific sites on the plate were then blocked with a heparin containing phosphate buffer, at room temperature for 1 hr (Pereira et al., 1989). The plates were washed and the primary antibody was then added to the plate and incubated for 1 hr at 37°C. Following this incubation the plate was washed and the second antibody was added and the plate incubated for 1 hr at 37°C. The second antibody was a goat anti-mouse immunoglobulin which is conjugated to horse-radish peroxidase. The color development step involves incubating the substrate (3.7 mM O-phenylenediamine) in citrate phosphate buffer, pH 5.0, containing 0.24 μ l/ml 30% H₂O₂ at room temperature for 30 min. The reaction is stopped with 2.5 M H₂SO₄ and the absorbance read immediately using a TITERTEK multiscan plate reader (Flow Laboratories) at 492 nm.

The results of the ELISA confirmed the results of the other analyses. The same samples as used for the SDS-PAGE were also used in the ELISA. Primary antibodies were prepared against each of these samples. The material from
5 Peak 2 reacted only with the antibodies prepared against a pure CAP37, while the material from Peak 1 reacted with the antibody prepared against Cathepsin G. The crude granule extract reacted with all the antibodies and the Peak C material reacted with antibodies for CAP37 and for Cathepsin
10 G.

For amino acid sequencing of the CAP37 protein a final desalting step using reverse phase HPLC was employed. A DYNAMAX 300A C8 column was equilibrated with 0.1% Trifluoroacetic acid in water the above-purified material
15 was then applied to the column. Elution of the purified protein was effected by a 30 minute elution with a 0-80% gradient of 0.1% Trifluoroacetic acid in acetonitrile at a flow rate of 1 ml per minute. The CAP37 protein containing sample corresponded to the 16.14 minute peak, as determined
20 by SDS-PAGE: this fraction was concentrated in a Savant Instruments SPEED VAC.

C. Antibodies to Purified CAP37 Protein

Ascites fluid containing antibodies against CAP37
25 protein was prepared by injecting BALB/c mice (Jackson Laboratories) with 250 ng of alum-adsorbed (Herbert) CAP37 protein emulsified in an equal volume of Freund's complete

and Freund's incomplete adjuvant (Difco Laboratories). Mice were subcutaneously injected with a total volume of 200 μ l of the above suspension. The mice were boosted three weeks later with 250 ng of alum-adsorbed CAP37 injected
5 intraperitoneally. At the same time the mice were injected with 1 ml of pristane (2,6,10,14 - tetramethyl pentadecane, Sigma). One week later 10⁷ SP2/0 mouse myeloma cells were injected intraperitoneally (Lacy et al.). Ascites fluid was collected. The specificity of the ascites fluid reactivity
10 against the CAP37 protein was demonstrated in ELISA assays (Pereira et al.) using CAP37, CAP57 (a cationic antimicrobial protein of mol. wt. 57,000 Da; Spitznagel et al.), lactoferrin, myeloperoxidase, cathepsin G and lysozyme as the antigens. Further, no cross reactivity between
15 Cathepsin G and CAP37 protein was observed by western blot analysis (Ausubel et al.).

For the immunocytochemical studies, the final cell concentration was adjusted to 1×10^6 nucleated cells per ml in 10% heat inactivated fetal bovine serum (Hyclone
20 Laboratories Inc., Utah) in PBS. One hundred microlitres of the cell suspension was cytocentrifuged onto glass slides. The cells were fixed in buffered formol acetone, pH 7.2 at 4°C for 60 seconds. The staining was performed using the VECTASTAIN Avidin Biotin Complex - Glucose oxidase (ABC-GO)
25 technique (Vectastain Laboratories, Burlingame, CA) as described previously (Spitznagel et al.). The above described monospecific polyvalent mouse anti CAP37 ascites

fluid (1:100) was used to stain the cells. Color development was obtained using the nitroblue tetrazolium salt (VECTASTAIN GO substrate kit I) at room temperature for 30 minutes. Normal mouse serum and phosphate buffered saline (PBS) served as the negative controls. Ascites fluid made against myeloperoxidase, a known marker of the primary granule of PMNs, served as the positive control.

D. Microsequencing of CAP37

The protein sequence analysis of CAP37 was performed using an Applied Biosystems Model 477A Protein/Peptide Sequencer with an on-line Applied Biosystems 120A PTH-Amino Acid Analyzer. Reagents and solvents were from Applied Biosystems, Foster City, CA. Phenylthiohydantoin (PTH)-derivatized amino acids formed sequentially by Edman degradation were separated using an Applied Biosystems PTH C-18 HPLC reverse phase microbore column (2.1 mm ID x 220 mm) by gradient elution. The sample was applied to an acid-etched glass-fiber filter which had been treated with 3 mg Biobrene (polybrene) and precycled. Peak identification and yield quantitation was based on a standard PTH-amino acid profile. The N-terminal end of the CAP37 protein was identified by standard microsequencing procedures (Applied Biosystems). Trypsin and chymotrypsin generated digestion fragments of CAP37, were separated and purified using hydrophobic and reverse-phase HPLC (Example 1-B). These fragments were then sequenced, as described above. When the

cloning of the cDNA was undertaken only the sequences shown in Table 1 had been determined. The sequences of the amino and carboxy termini of the mature CAP37 protein are designated in Table 1.

5

Example 2

Chemotactic Properties of the Purified Human CAP37

A. In Vitro Chemotaxis Assays

Chemotaxis was measured using the modified Boyden
10 chamber technique (Snyderman et al.). The leading front
method (Zigmond et al.) was used to assess migration of
monocytes and lymphocytes through a 8 μm filter (Millipore
Corporation, Bedford, MA). PMN chemotaxis was measured
using a 3 μm filter (Millipore). The purified CAP37 protein
15 (Example 1) used in chemotaxis assays were endotoxin-free as
determined by the Limulus Amoebocyte Lysate Assay (Whittaker
Bioproducts, Inc., Walkersville, MD). The dilutions of
CAP37 and N-formyl-methionyl-leucyl-phenylalanine (FMLP)
were made in Geys buffer (Gibco) containing 2% endotoxin-
20 free bovine serum albumin (BSA). Geys buffer containing 2%
BSA served as the negative control, and a 10^{-8} M solution of
FMLP as the positive control.

The chambers were incubated in a humidified atmosphere
(6.2% CO_2) for 2 hours when testing monocytes and
25 lymphocytes, and for 30 minutes when testing PMNs. The
filters were then removed and processed as previously
described (Snyderman et al.). The cells were viewed using

oil immersion and the distance the cells had migrated into the filter was determined over five different fields on the same slide (Zigmond et al.). Triplicate assays were performed for each experimental point.

5 The results are presented in Fig. 1. The data clearly show the strong chemotactic properties of the CAP37 protein.

CAP37 did not have any effect on PMN and lymphocyte chemotaxis in the range employed in these experiments. In addition to the observed chemotactic effect on human
10 monocytes, CAP37 at a higher concentration of 1000 ng/ml (2.7×10^{-8} M) was chemotactic for rabbit monocytes as well. The effect was selective for monocytes since rabbit PMN did not show a chemotactic response towards CAP37.

To distinguish directed cell movement (chemotaxis)
15 through the filters of a Boyden chamber as opposed to accelerated random cell motion (chemokinesis), the chemokinetic activity of CAP37 was determined by the checkerboard assay of Zigmond et al. The checkerboard assay demonstrated that in addition to its chemotactic properties,
20 CAP37 has some chemokinetic effect on monocytes.

B. In Vivo Chemotactic Assay

The purpose of these experiments is to document that CAP37 when injected in vivo into mice will result in the
25 emigration of monocytes/macrophages.

Female BALB/c mice (6 - 8 weeks) (Jackson Laboratory, Bar Harbor, MI) were injected intraperitoneally (i.p.) with

100 ng CAP37 (purified according to the method of the invention) per mouse in 2 ml RPMI-1640 serum-free medium (Mediatech). A control group of mice were injected i.p. with 2 ml brewers thioglycollate (4% w/v) (Difco Laboratories), a known stimulator of inflammatory cells whose action is well documented. A second control group of mice were injected i.p. with 2ml of RPMI-1640 alone.

(RPMI-1640 serum free medium from Mediatech has the following composition: $\text{CaNO}_3 \cdot 4\text{H}_2\text{O}$:100.00mg/L;

10 KCl :400.00mg/L; $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$:100.00mg/L; NaCl :6000.00mg/L; NaHCO_3 :2000.00mg/L; $\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$:1512.00mg/L; D-Glucose:2000.00mg/L; Glutathione (reduced):1.00mg/L; Phenol red:5.00mg/L; L-Arginine(free base):200.00mg/L; L-Asparagine:50.00mg/L; L-Aspartic acid:20.00mg/L;

15 L-Cystine:50.00mg/L; L-Glutamic acid:20.00mg/L; L-Glutamine:300.00mg/L; Glycine:10.00mg/L; L-Histidine (free base):15.00mg/L; L-Hydroxyproline:20.00mg/L; L-Isoleucine (Allo free):50.00mg/L;

20 L-Leucine (Methionine free):50.00mg/L; L-Lysine HCl:40.00mg/L; L-Methionine:15.00mg/L; L-Phenylalanine:15.00mg/L; L-Proline (Hydroxy L-Proline free):20.00mg/L; L-Serine:30.00mg/L; L-Threonine (Allo free):20.00mg/L;

25 L-Tryptophan:5.00mg/L; L-Tyrosine:20.00mg/L; L-Valine:20.00mg/L; Biotin:0.20mg/L; D-Ca pantothenate:0.25mg/L; Choline chloride:3.00mg/L;

Folic acid:1.00mg/L; i-Inositol:35.00mg/L;
Nicotinamide:1.00mg/L; Para-aminobenzoic acid:1.00mg/L;
Pyridoxine HCl:1.00mg/L; Riboflavin:0.20mg/L;
Thiamine HCl:1.00mg/L; and Vitamin B₁₂:0.005mg/L.)

5 At 6, 24, 48 and 72 hours following these i.p.
injections, four mice in each group were sacrificed by CO₂
anesthesia. Ten ml sterile medium was injected into the
peritoneal cavity of each mouse and the abdominal area
gently massaged to dislodge the exudate cells. The medium
10 containing the exudate cells was then aspirated from the
peritoneal cavity using a 19 gauge needle attached to a
syringe. The total number of cells in the peritoneal
exudate was determined by counting the cells on a COULTER
COUNTER (Coulter Electronics, Hialeah, Florida: The
15 operation of the COUTLER COUNTER is based on electrical
conductivity difference between particles and common
diluent. Particles act as insulators, diluents as good
conductors. The particles, suspended in an electrolyte, are
forced through a small aperture through which an electrical
20 current path has been established. As each particle
displaces electrolyte in the aperture, a pulse essentially
proportional to the particle volume is produced. Thus a 3-
dimensional particle volume response is the basis for all
sizing, regardless of position or orientation of the
25 particle in solution.) One hundred μ l of the peritoneal
exudate was cytocentrifuged onto a glass slide and the cells
stained with Wright's stain. A differential count of the

cells was made by counting the number of monocytes, lymphocytes, neutrophils, basophils and eosinophils per hundred consecutive cells. These experiments were performed to determine the time course of migration of neutrophils, 5 monocytes, lymphocytes and other cells into the peritoneal cavity, in response to an i.p. injection of CAP37.

Traditionally neutrophils are the first cells to migrate into the peritoneal cavity, and they do so about 6 hours after the i.p. injection. Monocytes emigrate much 10 later, generally 72 hours to 6 days after the i.p. injection.

The results, shown in Table 1 below, indicated that an injection of 100 ng of CAP37 into the peritoneal cavity, moderately increased the overall numbers of cells emigrating 15 into the peritoneal cavity. Nevertheless, monocytes appeared in the peritoneal cavity much earlier (24 hours) than when thioglycollate was used. Furthermore, the percentage of monocytes elicited with CAP37 (55%) was much greater than when sodium thioglycollate (33%) was used even 20 at the 72 hour time point. A further interesting observation was the dramatic reduction in neutrophils by 24 hours with the CAP37 injection whereas, with thioglycollate, the neutrophils persist at a very high percentage up to 48 hours (36%), and are still present at 72 hours (21%).

25 These responses with CAP37 contrasted markedly with responses to endotoxin in which far greater cell numbers are found to endotoxin in which far greater cell numbers are

found and PMN persist as the predominant cell type for at least 48 hours (Snyderman et al, J. Expe. Med. 134: 1131, 1971). The migration of monocytes into the peritoneal cavity following CAP37 injection into the peritoneal cavity of mice demonstrates the potent monocyte chemoattractant capacity of CAP37 in this in vivo animal model.

Table 1: Migration of cells following intraperitoneal injection with the inflammatory stimulus indicated.

10

Inflammatory Stimulus ^a	Hours post Injection	Total Cells ^b x 10 ⁶	%monocytes	%PMN
None	0	3.1	18	30
RPMI-1640	6	1.5	15	42
	24	2.2	12	11
	48	3.1	14	28
	72	2.8	43	5
Thioglycollate	6	9.5	4	65
	24	9.1	5	77
	48	8.4	20	36
	72	11.1	33	21
CAP 37	6	3.6	7	65
	24	3.8	27	26
	48	3.5	48	4
	72	3.3	55	3

30

^a Four mice per group

^b Mean value for each group of four mice

35

Example 3

Comparison of the CAP37 protein amino terminal sequence

Using the first 45 amino acids of the amino terminal end of the CAP37 protein, a search of a protein sequence data base was made using the FASTAMAIL program through the BIONET network. This search revealed substantial homologies with the amino termini of a subset of serine proteases which mediate a number of functions involved in the inflammation response (see Table 2: elastase, ELAST; complement factor D, FACTD; bovine plasminogen, PLASM; cathepsin G, CATG; rat mast cell protease I and II, RMCPI and RMCPII; cytotoxic T cell I, CCPI; cytotoxic T cell protease -- H Factor, HF).

The closest over-all homologies were obtained with two PMN-derived granular proteins: a homology of 57.5% with human elastase (Sinha et al.) also known as medullasin (Okano et al.) and a homology of 45% with human cathepsin G (Salvesen et al.). Other specific homologous sequences were seen with bovine plasminogen (45%) and human complement factor D (45.5%) (Johnson et al.; Nieman et al. et al.), which is the first enzyme involved in the activation of the alternative complement pathway.

Two other groups of proteins which demonstrated strong homology with the CAP37 protein were: (a) the group of serine protease-like molecules derived from granules of atypical rat mast cells -- rat mast cell protease I (Woodbury et al.), RMCPI, 38.6%, and rat mast cell protease II, RMCPII, 40% (Benfey et al.); and (b) two proteins from

cytotoxic T cells -- cytotoxic T cell protease I (Lobe et al.), CCPI, 40%, and cytotoxic T cell protease factor H (Gershenfeld et al.), HF, 38.6%.

5

Example 4

Isolation of a First cDNA having Homology to
Human CAP37 Protein

A. Preparation of poly-A mRNA

The starting material for the isolation of human CAP37-
10 encoding cDNA was tumor cell line HL60 (ATCC CCL240). Using
the anti-CAP37 specific antibodies that were described
above, the presence of an antigen reacting with these
antibodies was shown to be present in the HL60 cell line:
this cell line was chosen as the starting material for
15 cloning a CAP37 encoding cDNA. All of the following
procedures were carried out on ice and with RNase-free
materials.

Monolayers of HL60 were grown to confluence using
standard sera-supplemented minimal media (DMEM/10% Fetal
20 Calf Serum, 50 units/ml penicillin and 50 µg/ml
streptomycin) in 85 mm plates. Cells were grown to a
density of 10^6 cells/ml. Each plate was placed on ice and
washed four times with ice-cold phosphate buffered saline
(PBS) and a final 2 ml aliquot of PBS added to each plate.
25 The cells were harvested from each plate by scraping,
transferred by pipette to COREX centrifuge tubes, and held

on ice. When all the plates were harvested the cells were pelleted by centrifugation at 2000 X g for 5 minutes at 4°C.

RNA was isolated from 10^8 cells by the previously described method of Chirgwin et al. using guanidine isothiocyanate.

B. Selecting the poly(A) enriched mRNA fraction.

Oligo(dT) cellulose (0.1-1.0 g; purchased from Pharmacia) was suspended in 1-5 ml of elution buffer (distilled H₂O, 1mM EDTA), poured into a 1- to 4-ml disposable column, and washed with 5 column volumes of binding buffer (0.01 M Tris-HCl at pH 7.5, 0.5 M NaCl, 1 mM EDTA, 0.5% SDS). The isolated RNA was resuspended at 1-5 mg/ml in elution buffer, heated to 65°C for 5 min, quickly cooled in ice, diluted with an equal volume of 2X binding buffer, and applied to the column: the flow-through was collected and reapplied to the column. The column was washed with 5-10 volumes of binding buffer and 5 volumes of wash buffer (0.01 M Tris-HCl at pH 7.5, 0.1 M NaCl, 1 mM EDTA).

The bound RNA was eluted with 2-3 column volumes of elution buffer; subsequently, it is adjusted to a final concentration of 0.5 M NaCl (with 5 M NaCl or 2X binding buffer), re-bound, re-washed, and re-eluted as described above. The RNA in the final eluate was recovered by addition of 0.1 volumes of 3 M sodium acetate and precipitation with 2.5 volumes of ethanol. Sodium dodecyl

sulfate (SDS) is deliberately excluded from the wash and elution buffers to avoid precipitating the detergent from ethanol along with the RNA.

The final RNA sample was precipitated and dissolved in sterile water to a final RNA concentration of approximately 1 μ g/ μ l.

C. First-Strand cDNA Synthesis.

Double-stranded (ds) cDNA was synthesized using the Amersham cDNA synthesis kit. Briefly, 5 μ g of mRNA was added to the following reaction mixture: first strand synthesis reaction buffer, sodium pyrophosphate solution, human placental ribonuclease inhibitor (HPRI, 50 units), deoxynucleotide triphosphate mix (1 mM dATP, 1 mM dGTP, 1 mM dTTP, and 0.5 mM dCTP), 4 μ g oligo-dT, 100 units reverse transcriptase, and 5 μ Ci (α -³²P)-dCTP in a total volume of 50 μ l. The reaction was incubated at 42°C for 60 minutes.

D. Second-Strand cDNA Synthesis.

A final volume (250 μ l) containing the first strand synthesis mix was mixed with E. coli ribonuclease (4 units) and E. coli DNA polymerase I (115 units). This mixture was incubated at 12°C for 60 minutes, 22°C for 60 minutes, and 70°C for 10 minutes. T₄ DNA polymerase (10 units) was added and the sample incubated at 37°C for 10 minutes. The ds cDNA was phenol/chloroform extracted, chloroform extracted, and ethanol precipitated (Maniatis et al.).

E. Cloning of the Double Stranded cDNA.

For ease of manipulation the double stranded cDNA was tailed with EcoRI linkers in the following manner.

The cDNA was then resuspended in water and treated with
5 EcoRI methylase under the following conditions: 100 mM Tris HCl, pH=8.0; 10 mM EDTA; 80 μ M S-adenosyl-methionine; 100 μ g/ml bovine serum albumin; with approximately 100 units of EcoRI methylase (Promega) in a total volume of 50 μ l incubated at 37°C for 60 minutes. The cDNA was then
10 precipitated with ethanol.

The cDNA was resuspended in 5 μ l of dH₂O to which was added 2 μ l of 10x ligase buffer (0.5M Tris HCl, pH=7.4; 70mM MgCl₂; 10 and 1 μ l t4 DNA ligase (100 units). The mixture was incubated at 16°C overnight. The reaction mixture was
15 extracted once with phenol/chloroform and the cDNA precipitated with ethanol. The cDNA was then digested with EcoRI in a buffer containing 100 mM Tris-HCl (ph 7.5), 50 mM NaCl and EcoRI restriction enzyme (50 units) was incubated at 37°C for 3 hours. The ds cDNA was extracted,
20 precipitated, resuspended, and separated from the EcoRI linkers using a Sephacryl S-400 column.

Finally, the cDNA was size fractionated as follows before insertion into the vector. The cDNA was resuspended in the following buffer: 0.6 M NaCl, 20 mM Tris HCl
25 (pH=8.0), and 20 mM EDTA. This sample was then loaded on a SEPHACRYL S-400 column which was equilibrated with the same buffer. Fifty microliter aliquots were then collected and

assayed by electrophoresis through an alkaline agarose gel to identify the fractions containing labelled cDNA molecules of greater than 400 base pairs (bp) in length. These >400 bp fractions were then pooled and the cDNA precipitated with
5 ethanol.

The vector for insertion of the >400 bp cDNA molecules was EcoRI digested and phosphatased gt10 (Stratagene). A Stratagene Gigapack Gold Packaging Extract Kit was used to package the Lambda gt10/cDNA ligation mixture. A primary
10 titer of 1×10^7 PFU's was obtained.

Plaques resulting from recombinant phage, carrying the cDNA, were then picked to fresh lawns of C600. Nitrocellulose filters (Schleicher and Schuell) were then presoaked in a cell suspension of C600Hfl (a less permissive
15 host strain) and dried. The coated nitrocellulose filters were then layered onto the phage-containing agar plates to transfer phage particles to the filters. Duplicate filters were prepared.

When the bacterial lawn had grown and plaques were
20 apparent the filters were then employed in in situ hybridization after the method of Woo. A primary screen of 500,000 clones at 50,000 PFU/plate was performed using duplicate filters. Briefly, the filters were lifted from the plates and placed on WHATMAN 3MM filters saturated with
25 0.5 M NaOH and 1.5 M NaCl to lyse the bacteria and phage particles. The filters were neutralized by successive transfer to WHATMAN filters saturated with, first, 0.5 M

Tris HCl, pH=7.4, with 1.5 M NaCl, and, second with 2X SSC (Maniatis et al.). The nitrocellulose filters were then blotted dry, air dried, and baked under vacuum at 68°C for 2 hours.

- 5 The filters were prehybridized with 1X PAM containing 30% formamide. (A 1 liter solution of 2X PAM contained: 200 ml 50X Denhardts; 500 ml 20X SSC; 100 ml 1M NaH₂PO₄, pH=7.0; 20 ml 100 mM PPI; 100 mM Na₂HPO₄; 100 ug/ml sonicated salmon sperm DNA; and, 120 mg ATP.) The
- 10 prehybridization solution was removed. The hybridization was performed overnight, at 42°C, in a solution of 1 x PAM containing 30% formamide and a labeled probe set.

- Two sets of probes were used to screen the duplicate filters. These probes were two sets of short
- 15 oligonucleotides made to the amino-terminus of the CAP37 protein (Table 1) as follows:

 Oligo 1 (Cap37a-1), non-coding strand, amino acids 18-24,

 5'-C(GT)GCCTCC(TC)TG(AG)TT(CT)TG(AG)AT-3';

- 20 Oligo 2 (Cap37a-2), non-coding strand, amino acids 9-15,

 5'-A(GA)GAAGGG(AG)AA(CT)TG(CATG)C(GT)GGG-3'.

Bases presented in parenthesis are alternative insertions at that site.

- 25 The two sets of probes were 5' end-labelled using [³²P]ATP and T₄ Polynucleotide kinase (Bethesda Research Laboratories, 5'DNA Terminus Labelling System). Each set of

duplicate filters were hybridized, as described above, with one of the probe sets. The filters were then washed as follows: 2 x SSC wash at 4°C (2x15 minutes) followed by a 3 M (CH₃)₄NCl wash at 53°C (2x15 minutes). The filters were then dried and subjected to radioautography at -20°C using intensifying screens. The duplicate filters showed one recombinant plaque that was convincingly positive with both probes.

10

Example 5

Analysis of the First cDNA insert in Lambda gt10

The restriction map of the cloned cDNA was determined; no internal EcoRI sites were detected in the sequence. The approximately 850 bp insert was removed from the gt10 vector by digestion with EcoRI; the corresponding DNA fragment was resolved and subsequently isolated from a polyacrylamide gel (Maniatis et al.). This EcoRI fragment was then cloned into the unique EcoRI site of the vector pcDNAI (Fig. 2; Invitrogen, San Diego, CA).

20

The vector pcDNAI has a Col E1 origin of replication derived from pBR322, the CMV promoter sequences and a polyadenylation signal available for expression in mammalian cells (such as COS7), and a poly-linker flanked by opposing T₇ and SP6 promoters providing for ease of expression of inserted DNA sequences in bacteria. The vector is also useful for DNA sequencing in that region of the poly-linker

25

provides for the use of a universal primer homologous to the T₇ and SP6 promoters.

The region containing the CAP37 coding region was sequenced by standard double-strand sequencing methods (Pharmacia Sequencing Kit, Pharmacia), starting with the universal sequence primer discussed above, as well as unique synthetic oligonucleotide primers derived from the CAP37 coding sequence as they were needed. The sequence of the first cDNA clone having homology to the CAP37 coding region is shown in Table 3.

Example 6

Characteristics of the First cDNA

The first cDNA sequence was translated into its corresponding amino acid (aa) sequence. A continuous open reading frame exists from nucleotide 176 to 856. This sequence was then aligned to the peptide fragments determined from microsequencing of the purified CAP37 protein (Table 1). A DNA sequence encoding a protein sequence corresponding to the amino terminus of the mature CAP37 protein sequence begins at nucleotide 320. The cDNA encodes a protein in which the first amino acid of the mature protein is preceded by an in-frame open reading frame corresponding to an additional 48 amino acids. Further, the carboxy terminus of the cDNA encoded protein contained an extension, Gly Pro Ala, not present in the mature protein.

In matching the translated cDNA to the protein sequences in Table 1 a problem was encountered in the cDNA sequence. The sequence of interest in CAP37 first cDNA is as follows:

```

5  ATG CTG CTT CAG AGG TTT GTC AAC GTG ACT GTG ACC CCC GAG GAC
    M  L  L   Q * R   F   V   N   V   T   V   T   P   E   D
    CAG TGT CGC CCC ACC ACC GTG TGC ACC GGT GTG CTC ACC CGC CGC
    Q   C   R   P   N   N   V   C   T   G   V   L   T   R   R
    GGT GGC ATC TCG AAT GGG GAC GGG GGC ACC CCC CTC GTC TGC GAG
10  G   G   I   C   N   G   D   G   G   T   P   L   V   C   E
    CCG CTG GCC CAC GGC
    G   L   A   H   G.

```

This sequence corresponds in part to PE-V10, an internal peptide of the CAP37 protein (amino and carboxy terminii were identified, see Table 1). A partial sequence of the PE-V10 peptide follows here:

Ala Gly Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg
 Ser Gly Gly Arg Leu Ser Arg Phe Pro * Arg Phe Val Asn
 Val Thr Val Thr Pro Glu Asp Gln Cys Arg.

The 19 amino acids preceding the asterisk in the PE-V10 sequence were not represented in the first cDNA: the point of divergence in the cDNA sequence is also marked by an asterisk. Accordingly, while the first cDNA apparently coded for the majority of the CAP37 protein, it was not the correct cDNA.

The mature C-terminal sequence of the CAP37 protein (peptide PE-T19) indicates that there is also a carboxy

terminal extension present in the cDNA CAP37 protein coding sequence which is not present in the mature protein.

Example 7

5 Isolation of a Second cDNA having Homology
 to Human CAP37 Protein

A. Amplification of a fragment spanning the region of
 discrepancy between the cDNA sequence and the
 protein sequence.

10 As a first step to clone a cDNA containing the complete
CAP37 coding sequence, an attempt was made to amplify a
specific DNA fragment which would span the region where the
discrepancy between the cDNA sequence and the protein
sequence was observed. A degenerate oligonucleotide probe
15 corresponding to the amino acids CQVAGWG (underlined in the
CAP37 peptide sequence presented in Example 6) was
synthesized. The oligonucleotide was a 20mer (256 fold
degenerate, designated Intrlc), synthesized as follows:

20 5'TG(CT)CA(AG)GT(ACTG)GC(ACTG)GG(ACTG)TGGGG 3',

where the bases in parenthesis are alternative substitutions
at that site.

As a second primer for use in DNA amplification a
25 number of 20mer primers were designed from the sequence of
the non-coding strand of CAP37 first cDNA.

Total human genomic DNA was used as template in DNA
amplification reactions (Mullis; Scharf et al.) involving

the above described primers. The amplification reactions were divided into two samples and each set of samples were fractionated on an agarose gel. The samples in one half of the gel (representing a complete set of amplification reactions) were transferred to nitrocellulose (Maniatis et al.). The nitrocellulose filter was hybridized (Maniatis et al.) with radiolabelled CAP37 first cDNA (Bethesda Research Laboratories Nick Translation Kit) as a probe.

The Southern blot hybridization showed one positive band. This band was generated using primer Intrlc (above) and a non-coding strand 20 mer designated 669nc (corresponding to base pairs 652-671 of CAP37 first cDNA, Table 3). The region of the second half of the agarose gel corresponding to the positive band was excised and the DNA extracted, phenol/chloroform extracted, and precipitated (Ausubel et al.). The band was then sequenced using the Intrlc/669nc primers (Pharmacia Sequencing Kit, Pharmacia).

The sequence of Intrlc/669nc generated band was as follows:

20

TGTAG GTT GCG GGT TGG GGG AGC CAG CAC AGT GGG GGG CGT CTC
TCC CGT

V A G W G S Q H S G G R L

S R

25

TTT CCC AGG TTC GTC AAC GTG ACT GTG ACC CCC GAG GAC CAG TGT
CGC CCC

60

F P R F V N V T V T P E D Q C
R P

AAC AAC GTG TGC ACC GGT GTG CTC

5 N N V C T G V L .

B. Second Screening of the lambda gt10/HL-60 cDNA library for a CAP37 cDNA.

A 50mer corresponding to a region of the Intrlc/669nc
10 sequence which was not present in the CAP37 first cDNA clone
was synthesized and used as a probe to screen 200,000 clones
at 50,000 PFU/plate (as in Example 4).

The sequence of the oligonucleotide probe was as
follows:

15 5' TGTCAGGTTGCGGGTTGGGGGAGCCAGCACAGTGGGGGGCGTCTCTCCCG
3'.

On an initial screen 11 positives were identified of
which 5 remained positive following a secondary screen. The
EcoRI cDNA fragment of one of these clones, designated 6a.1,
20 was subcloned into the pcDNAI vector and sequenced using
dideoxy sequencing: the 6a.1 insert subclone in pcDNAI was
designated pcDNA-CAP#2. The complete DNA sequence of the
6a.1 clone is illustrated in Table 4. The plasmid pcDNA-
CAP#2 has been deposited under the terms of the Budapest
25 Treaty with the American Type Culture Collection (12301
Parklawn Dr., Rockville MD 20852 USA) and given accession
number ATCC 68340.

Example 8

Characteristics of the 6a.1 cDNA Encoded Protein

The 6a.1 cDNA sequence was translated into its corresponding amino acid (aa) sequence. A continuous open
5 reading frame exists from nucleotide 4 to 756. This sequence was then aligned to the peptide fragment sequences obtained from microsequencing of the purified CAP37 protein (Example 1). The corresponding DNA coding sequence begins at nucleotide 82. All of the protein sequences determined
10 by microsequencing of the purified CAP37 protein had corresponding protein sequences in the 6a.1 cDNA encoded protein.

The 6a.1 cDNA encodes a protein in which the first amino acid of the coding sequence of the mature protein is
15 preceded by an in-frame open reading frame corresponding to an additional 26 amino acids: these 26 amino acids do not correspond to those seen in the first cDNA protein. The first approximately 20 amino acids of this region have a high degree of hydrophobicity (Fig. 3). The length of the
20 sequence and the degree of hydrophobicity make this sequence an ideal candidate for a eucaryotic secretory signal sequence. The hydropathy index plot was generated using the SOAP program of PCGENE (Intelligenetics, Mountain View, CA). The SOAP program uses the method of Kyte et al to plot the
25 hydropathicity of the protein along its sequence. The interval used for the computation was 11 amino acids.

The cDNA encoded protein apparently has a carboxy terminal extension relative to the mature CAP37 protein, i.e. Gly Pro Ala.

The portion of the open reading frame corresponding to the mature form of the protein has an estimated molecular weight of 24,276 daltons. The molecular weight previously determined for the CAP37 protein, i.e. approximately 37,000 daltons (Shafer et al., 1986), was obtained from SDS-PAGE of the purified protein. The discrepancy in molecular weight is most likely the result of post-translational modification of the CAP37 protein. For example, the CAP37 sequence has three potential N-glycosylation sites, as determined by PROSITE analysis (PCGENE Intelligenetics, Mountain View, CA) of the 6a.1 cDNA coding sequence. These potential glycosylation sites are located at asparagine residues 100, 114, and 145 of the mature sequence.

Using the method of Hopp et al. (ANTIGEN program, PCGENE Intelligenetics, Mountain View, CA) the primary antigenic determinants of the CAP37 protein sequence were determined. The three highest points of hydrophilicity are from residues 61 to 66, 5 to 10, and 150 to 156 of the mature protein sequence, with the highest average hydrophilicity value being for residues 61-66.

Example 9

Expression of Recombinant CAP37 Protein from the
6a.1 cDNA Coding SequenceA. Expression of CAP37 in E. coli.

- 5 The following primers are used for DNA amplification of
the CAP37 coding DNA fragment from the CAP37 cDNA clone
(Example 7): 5'-ATCGTTGGCGGCCGGAAGGCG-3'; and, 5'-
TTGGGCCCTGGCCCCGGTCGG-3'. These primers result in the
amplification of the CAP37 mature protein coding sequence.
- 10 If a 5' methionine is required for expression the first
primer can be modified to 5'-ATGATCGTTGGCGGCCGGAAGGCG-3' to
generate amplified fragments encoding a 5' methionine.
Primers can also be designed to result in amplification of
the precursor form of the CAP37 protein, for example, 5'-
15 ATGGGGGAGGGTGGGTCC-3', and the same second primer as above.

Following confirmation by DNA sequencing, the amplified
DNA fragment is blunt-end ligated (Maniatis et al.) in-frame
into a plasmid expression vector (Smith et al.) designed to
direct synthesis of foreign polypeptides as fusions with the
20 protein Sj26; Sj26 is a glutathione S-transferase protein
from Schistosoma japonicum (Smith et al.). Further, Smith
et al. have described an expression vector encoding a
thrombin cleavage site immediately adjacent the carboxy
terminus of Sj26 at the site where the amino-terminal of the
25 foreign protein is fused. E. coli strain JM101 is then
transformed (Maniatis et al.) with either (i) the plasmid

containing the fusion protein coding sequences, or (ii) the parent plasmid without the CAP37 sequences.

The transformed cells are grown, expression of the desired proteins induced with IPTG (Smith et al.), and the
5 cells grown a further 3-6 hours before harvest. As a control transformed cells are also grown and not induced with IPTG.

The harvested cells are then lysed (Smith et al.). A portion of each lysate is subjected to SDS-PAGE to test for
10 expression of the fusion protein by size comparison to the native Sj26 protein and to protein molecular weight size standards. A band traveling at the molecular weight predicted for the fusion protein is expected from the lysate containing the fusion protein coding sequences, but not from
15 lysates from cells transformed with parent vector alone or from those not induced with IPTG.

The bulk of the fusion-protein-containing lysate is treated with immobilized glutathione to purify the fusion protein (Smith et al.). This purified fusion protein is
20 then subjected to SDS-PAGE to examine the relative purity of the preparation. The purified fusion protein is cleaved with thrombin (Boehringer-Mannheim) and the CAP37 separated from the Sj26 protein by chromatography (e.g., size exclusion chromatography followed by an ion exchange column
25 as in Example 1).

B. Expression of CAP37 in Yeast.

For expression of CAP37 in yeast, pre-pro-alpha-factor/CAP37 gene fusions are constructed. The DNA amplified CAP37 cDNA used above for construction of E. coli vectors is also used for construction of yeast vectors. The expression vector contains the yeast alcohol dehydrogenase I transcription promoter and terminator (Oeda et al.). The CAP37 cDNA is blunt-end ligated, in-frame (Maniatis et al.) directly following the Lys-Arg dipeptide sequence of the pre-pro-alpha-factor leader (Kurjan et al.). This expression vector construct directs synthesis, secretion and processing of the hybrid protein in yeast.

In order to maximize protein product yield the expression vector containing the CAP37 cDNA is transformed (Ausubel et al.) into a yeast strain carrying the pep4 mutation (Jones); such strains are defective in four major vacuolar proteases and RNase. The CAP37 protein is purified from the media by a combination of size fractionation followed by ion-exchange chromatography (Example 1). Alternatively, the yeast cells are mechanically lysed (Guarente) and the CAP37 protein isolated from the lysate in the same manner.

C. Expression of CAP37 in Mammalian Cells.

25 (i) Modification of CAP37 cDNA.

The cDNA clone encoding CAP37 was modified to be bounded by a HindIII restriction site at the 5' end of the

sequence and a XbaI site at the 3' end as follows. Two primers for use in DNA amplification reactions were designed to be complementary to the ends of the CAP37 cDNA and contain the desired restriction sites. The sequence of the two primers used to prepare the DNA amplification product were:

5': 5'-CCGGAATTCCAAGCTTCCACCATGACCCGGCTGACAGTCCTGG-3'
HindIII

10 3': 5'-CCGGATCCTCTAGACCCTAGGCTGGCCCCGGTCCCGG-3'.
XbaI

The DNA was amplified as per the manufacturers instructions (Cetus-Perkin Elmer, Norwalk CT). The resulting 5' end contained a HindIII site followed by the consensus mammalian initiator sequence CCACCATG.

(ii) Construction of Vectors.

The above modified CAP37 cDNA was inserted into a series of expression vectors having the following properties:

- 20 1. Unique HindIII and XbaI cloning sites situated between a strong viral promoter (either CMV, SV40, or RSV) and a polyadenylation signal derived from SV40).
 2. A selectable marker linked to the vector conferring either Genetimicin resistance or methotrexate resistance.
- 25 The vectors are shown in Fig. 4.

In Fig. 4, plasmid vector sequences derived from pUC18 are denoted by the thin line. The promoter preceding the CAP37 cDNA insert was joined to the pUC polylinker at the EcoRI site. The cytomegalovirus (CMV) promoter cassette (pCXSD-CAP37 and pCXRD-CAP37) was a 637 bp fragment which contains the promoter and enhancer of the immediate early gene 1 (IE1) of CMV (Seed). The promoter cassette was modified to be bounded by an EcoRI restriction site at the 5' end of the cassette and HindIII and BglII sites at the 3' end of the cassette. The SV40 sequences flanking the 3' end

of the CAP37 cDNA insert was composed of two elements from the SV40 early region. A 620 bp Sau3A fragment spanning the T antigen splice signal was joined to the 350 bp BclI-BamHI fragment of SV40 which spanned the polyadenylation signal of the SV40 early gene (Seed). The dihydrofolate reductase (DHFR) cassette was derived from a murine cDNA encoding DHFR and modified to contain a BglII site preceding the translational start site of the clone and ending at a SalI restriction site situated adjacent to the BglII restriction site of DHFR (Simonsen et al.). The SV40 E promoter cassette, at the 5' end of the DHFR insert in pCXSD-CAP37, was a 540 bp fragment which spanned the SV40 origin of replication, early, and late promoters, and is bounded by an EcoRI (Simonsen et al.). This SV40 promoter cassette can also be used for expression of the CAP37 cDNA (e.g., pSXRD-CAP37). The RSV promoter cassette, at the 5' end of DHFR in pCXRD-CAP37 and pSXRD-CAP37, was derived from the Rous Sarcoma Virus and spans the LTR, ending at a point 90 base pairs downstream of the transcriptional start site (Seed). The HBV 3' end of the each vector was a 585 bp BamHI-BglII fragment which spanned the HBV surface antigen polyadenylation signal (Simonsen et al.).

(iii) Derivation of Transformed Cell Lines.

Host cell lines which can be transformed using the above described vectors include human, mouse, and hamster. The preferred host cell line is a Chinese Hamster Ovary cell line (CHO) which has been rendered incapable of producing the enzyme dihydrofolate reductase (Urlaub et al.): the expression of CAP37 is not limited to this line. Typically, use of vectors containing a gene encoding dihydrofolate reductase (DHFR) has allowed for the efficient selection of stable cell lines expressing the transfected plasmid. In addition, such cell lines are capable of being selected with the folate analogue methotrexate, resulting in the emergence of cells having amplified copies of the DHFR cDNA and the

co-transfected sequences (Simonsen et al.; McIvor et al.; McGrogan et al., 1988 A).

Plasmid DNA containing the CAP37 protein encoding cDNA and the DHFR-encoding gene was transfected into CHO cells using the cationic liposome method (DOTMA). 2 x 10⁵ cells were passaged into 5-25 flasks 48 hours prior to the transfection and allowed to grow in non-selective media. Ten ug of plasmid DNA was diluted to 50 ul with sterile distilled water and then added to 25 ug of DOTMA (Lipofectin, Bethesda Research labs) in a volume of 50 ul. The DNA was mixed and allowed to stand 30 minutes at room temperature. Immediately prior to the addition of the DNA to the cells, the T-flasks were washed three times with serum-free media. Three milliliters of serum-free media was added to each T-flask, after which the DOTMA-DNA mixture was added to the cells. The flasks were swirled and returned to the incubator for 4 hours. Three milliliters of fresh media with 20% serum was then added to each flask of cells and the cells allowed to incubate for 48-72 hours at which time the cells were removed by trypsinization, split into 10 cm dishes, and suspended in selective media containing methotrexate.

The cells were returned to the incubator and allowed to grow with twice-weekly changes of media. After 2-3 weeks, colonies become apparent. Cloning cylinders were used to isolate and subclone colonies arising from an individual transfected cell.

Both bulk populations and subclones were expanded for protein assay by Western blot assays (Ausubel et al.). Cell lines expressing CAP37 antigen were selected for amplified CAP37 expression by growing the cells in stepwise increasing levels of methotrexate (MTX). Cell lines resistant to 1 μ M MTX were subcloned and characterized by Northern and Southern analysis (Maniatis et al.), doubling time, expression levels and stability of expression.

In addition to the above bacterial, yeast, and mammalian systems there are numerous expression systems, well known to one of ordinary skill in the art, available suited to the expression of CAP37 (eg., Kingsman et al.;
5 Brake, 1989; Revel et al.; Moriarty et al.; Kopchick et al.).

For all of the above expression systems antibodies generated to the CAP37 protein, or portions thereof, (Examples 1 and 13) can be used to follow and to quantitate
10 the CAP37 produced; the antibodies are particularly useful for following the purification of CAP37 as, for example, described above in the E. coli system.

Example 10

15 Preparing Cloned Peptide Fragments

A. DNA Fragment Digestion.

The amplified 6a.1 CAP37 cDNA described above in Example 9 is modified by treatment with EcoRI methylase under standard conditions (Promega). The DNA is
20 phenol/chloroform extracted and ethanol precipitated. The modified DNA is suspended in a standard digest buffer (0.5M Tris HCl, pH 7.5; 1 mg/ml BSA; 10mM MnCl₂) to a concentration of about 1 mg/ml and digested with DNase I at room temperature for various times (1-5 minutes). These
25 reaction conditions were determined from a prior calibration study, in which the incubation time required to produce predominantly 100-200 basepair fragments was determined. The material was extracted with phenol/chloroform before ethanol precipitation.

30 The fragments in the digest mixture were blunt-ended using DNA Polymerase I (Maniatis et al.) and ligated with the EcoRI linkers. The fragments were then digested with EcoRI under standard conditions (Promega). The resultant fragments were analyzed by electrophoresis (5-10V/cm) on
35 1.2% agarose gels, using PhiX174/HaeIII and lambda/HindIII size markers. The 50-200 bp fraction was eluted onto NA45

strips (Schleicher and Schuell), which were then placed into 1.5 ml microtubes with eluting solution (1 M NaCl, 50 mM arginine, pH 9.0), and incubated at 67°C for 30-60 minutes. The eluted DNA was phenol/chloroform extracted and then
 5 precipitated with two volumes of ethanol. The pellet was resuspended in 20 µl TE buffer (0.01 M Tris HCl, pH 7.5, 0.001 M EDTA).

B. Cloning the Digest Fragments.

10 The pUC7 plasmid (Messing) is modified to encode a collagenase (EC 3.4.24.3, from Clostridium histolyticum, available from Boehringer Mannheim) cleavage site using the following linker:

15 GAT CCG CCT GCA GGC CCT GTA AGC TTG AGG
 GC GGA CGT CCG GGA CAT TCG AAC TCC AGC T

BamHI

HindIII

Sali.

20 Insertion of the above linker between the BamHI and Sali sites of the pUC7 plasmid results in the introduction of a collagenase cleavage site (Pro Ala | Gly Pro Val), and a diagnostic HindIII site into the plasmid (designated pUC7-C). Further, the linker maintains a contiguous open reading
 25 frame into the β -galactosidase protein coding sequence. The phosphorylated oligonucleotides are synthesized by standard methods. The oligonucleotides are then mixed in an equimolar amount, heated and renatured by cooling to form the above duplex linker.

30 The pUC7-C plasmid is digested with EcoRI and treated with calf-intestinal phosphatase (Promega). The digest fragments from Part A were introduced into the EcoRI site by mixing 0.5-1.0 µg EcoRI-cleaved pUC7-C, 0.3-3 µl of the above sized fragments, 0.5 µl 10X ligation buffer (Maniatis
 35 et al.), 0.5 µl DNA ligase (200 units), and distilled water to 5 µl. The mixture was incubated overnight at 14°C.

The ligation mixtures are then transformed into E. coli strain JM101 and plated on YT media (Gibco) containing ampicillin (100 µg/ml) at a density of 300-500 colonies per plate. The plates are replica-plated to X-gal indicator plates (Miller), YT+amp, and to nitrocellulose filters (Grunstein et al.). Blue colonies are scored on the X-gal indicator plates and indicate possible in-frame fusions of an inserted DNA fragment (Part A) to the lacZ gene contained in the vector. The nitrocellulose filters are screened as follows. The amplified 6a.1 cDNA is digested with the restriction enzyme HaeIII under standard reaction conditions (New England Biolabs): the 6a.1 cDNA has 19 HaeIII sites. The resulting DNA fragments are then phenol/chloroform extracted and precipitated with ethanol. The DNA is resuspended and radioactively labelled by nick-translation (Bethesda Research Laboratories). The nitrocellulose filters are hybridized with the labelled 6a.1 cDNA as previously described (Grunstein et al.). The filters are then washed and subjected to autoradiography.

pUC7-C vectors which contain inserts from the 6a.1 cDNA will test positive by this screen. These positive colonies are further screened by comparison to the colonies on X-gal plates. Bacterial colonies which test positive for the presence of a fragment of the 6a.1 cDNA and are blue are candidates for in-frame fusions of fragments of the CAP37 coding sequence to α -galactosidase.

These candidates are picked to master plates. The candidates are inoculated into YT+ampicillin (Maniatis et al.) and grown to mid-log phase. The cultures are combined in groups of 5. The combined cells are pelleted by centrifugation and suspended in lysis buffer (10 mM Tris, pH=7.4, containing 2% Triton X-100™, with 1% aprotinin added just before use). The resuspended cells are frozen in liquid nitrogen, then thawed, resulting in substantially complete cell lysis. The lysate is treated with DNaseI to digest bacterial DNA, as evidence by a gradual loss of

viscosity in the lysate. Non-solubilized material is removed by centrifugation.

SEPAHAROSE 4B beads conjugated with anti-beta galactosidase are purchased from Promega. The beads are
5 packed in a column and washed successively with phosphate-buffered saline with 0.02% sodium azide and 10 ml TX buffer (10 mM Tris buffer, pH 7.4, 1% aprotinin). The clarified
10 lysate material is loaded on the SEPHAROSE column, the ends of the column are closed, and the column is placed on a rotary shaker for 2 hrs. at room temperature and 16 hours at 4°C. After the column settles, it is washed with TX buffer. The CAP37 protein fragments are released by collagenase cleavage (Scholtissek et al.; Ullmann). The eluent is then concentrated by ultrafiltration.

15

Example 11

Characterization of CAP37 Protein Fragments

A. Identification of CAP37 fragments having chemotactic properties.

20 The eluents generated in Example 10 are evaluated for their effects on human monocyte chemotaxis by the method of Cates et al. Briefly, one filter at a time is placed in the Boyden chamber (Neuroprobe, Bethesda MD). The eluent to be analyzed for its chemotactic activity is placed in the lower
25 chamber. A cell suspension of monocytes is placed in the upper compartment. The filled chambers are then briefly spun in a Sorvall centrifuge, covered to prevent evaporation, and incubated at 37°C for approximately 120 minutes.

30 The filters are then removed from the Boyden chamber, stained, and fixed. The number of monocytes adhering to the

chemoattractant side of the filter represent a fraction of the cells that have migrated through the filter in response to the chemoattractant. The number of monocytes in a 5 X 5 mm grid is counted for 10 randomly selected high-power
5 fields (10 X ocular, 45 X objective) for each filter and an average cell number per grid value determined.

The number of cells migrating in response to buffered HBSS (Hank's Balanced Salt Solution; Gibco, Grand Island NY) alone is also determined and is subtracted from the average
10 number of cells per grid migrating in response to the potential chemoattractant. The number of cells migrating in response to the CAP37 protein, also determined as just described, is used as a positive control to represent 100% chemotactic activity. The eluents are evaluated as the
15 percent of the control chemotactic activity as follows:

$$100 \times \frac{\text{corrected average number of cells per grid eluent}}{\text{corrected average number of cells per grid CAP37}}$$

An average of three filters per eluent are tested in
20 addition to the above controls. When a pool of eluent is identified as containing a chemotactic agent, the clones comprising the pool are individually tested in the above manner to identify the clone(s) responsible for the chemoattractant property.

25

B. Identification of CAP37 fragments having lipopolysaccharide binding properties.

Pooled eluent is prepared as described in Example 10-A. The eluents are tested for lipopolysaccharide neutralizing
30 capacity using the Limulus Amebocyte Lysate (LAL) Assay as previously described by Warren et al. Briefly, the pooled

eluent sample is diluted 1:1 in normal saline (USP Abbott Laboratories, Chicago IL) and added to serial two-fold dilutions, made in normal saline, of E. coli lipopolysaccharide (Whittaker Bioproducts, Inc., Walkersville, MD) contained in wells of a 96 well microtiter plate (Flow Laboratories, McLean VA). The mixtures are incubated for approximately 3 hours at 37°C followed by the addition of reconstituted LAL (Whittaker Bioproducts, Inc., Walkersville, MD). The reactions are incubated for 1 hour at 37°C and then read using a microplate reader (Flow Laboratories, McLean VA) set at 380 nm.

To evaluate LPS neutralization capacity of the eluent, the results of the above assays are plotted and the LPS concentration needed to produce 50% of the maximal increase in O.D.₃₈₀, i.e. the maximum O.D. produced in the presence of excess LPS, is determined by interpolation. This value is called the 50% limulus gelatin response (LR₅₀; Warren et al.).

Each microtiter plate has the following two controls:

(i) a saline control, that is, no potential neutralizing agent; and, (ii) a dilution of purified CAP37 protein as a neutralizing agent control. LR₅₀ values elevated above the saline control indicate potential LPS neutralizing peptide fragments of the CAP37 protein. When a pool of eluent is identified as containing a potential LPS neutralizing agent, the clones comprising the pool are individually tested in

the above manner to identify the clone(s) responsible for the LPS neutralizing property.

C. Characterization of Identified Clones.

5 The CAP37-encoding inserts of clones identified as of interest for either chemotactic or LPS binding properties are sequenced using dideoxynucleotide double-strand sequencing (Pharmacia Sequencing Kit, Pharmacia). Universal primers, corresponding to vector sequences which flank the
10 inserts, are employed in the sequencing reactions. The insert sequences are then aligned with the complete CAP37 sequence to identify the locations of these regions of interest in the corresponding CAP37 protein sequence.

15

Example 12

Alternative Method for Identification of Peptide Fragments and Chemotactic Activity of said Fragments

The amino acid sequence of CAP37 was compared to that of elastase and cathepsin G, two serine proteases with which
20 CAP37 has close homology. Because neither elastase nor cathepsin G exhibit monocyte chemotaxis, stretches of the CAP37 molecule which were the least homologous to either cathepsin G or elastase were selected as fragment likely to have monocyte chemotactic activity. Three such fragments,
25 depicted in Table 5, were identified and synthesized using standard peptide synthesis techniques.

The three peptides were tested for chemotactic activity towards monocytes using the modified Boyden Chamber technique described in Example 2. The monocyte chemotactic
30 activity of each peptide fragment at concentrations ranging from 10^{-7} to 10^{-13} M was compared with Geys buffer (negative

control), FMLP 10^{-8} M (positive control) and purified CAP37 10^{-9} M (positive control). Peptides 1 and 3 showed chemotactic activity for monocytes while peptide 2 did not. The effect of peptide 1 on monocyte chemotaxis is illustrated in Table 6 while the effect of peptide 3 on monocyte chemotaxis is illustrated in Table 7. The results with both peptides 1 and 3 show that significant chemotaxis occurs at 10^{-10} M concentration.

10

Example 13

Preparation of Anti-CAP37 Antibodies

The fusion protein containing the full length CAP37 protein and glutathione S-transferase (Example 9-A) is isolated from lysed bacteria. Transformed bacteria are streaked for single colonies, grown at 37°C overnight or until colonies are apparent. Individual colonies are inoculated into 1 ml of selection media and grown overnight. Saturated overnight bacterial culture are used to inoculate cultures, which are incubated with aeration to an O.D. of about 0.5-0.6. The cells are pelleted by centrifugation, and resuspended in lysis buffer (62 mM Tris, pH 7.5 containing 5% mercaptoethanol, 2.4 % SDS and 10% glycerol). The lysate is treated with DNaseI to digest bacterial DNA, as evidence by a gradual loss of viscosity in the lysate. Non-solubilized material was removed by centrifugation. The fusion protein is isolated from the bacterial lysate by treatment with immobilized-glutathione (Smith et al.).

For the isolation of CAP37/ β -galactosidase fusion proteins (Examples 10 and 11), the cells are pelleted by centrifugation and suspended in lysis buffer (10 mM Tris, pH 7.4 containing 2% TRITON X-100 and 1% aprotinin added just before use). The resuspended cells are frozen in liquid nitrogen, then thawed, resulting in substantially complete cell lysis. The lysates are treated with DNaseI to digest bacterial DNA, as evidence by a gradual loss of viscosity in

the lysate. Non-solubilized material is removed by centrifugation.

SEPHAROSE 4B beads conjugated with anti-beta galactosidase are purchased from Promega. The beads are packed in columns and washed successively with phosphate-buffered saline with 0.02% sodium azide and TX buffer (10 mM Tris buffer, pH 7.4, 1% aprotinin). The clarified lysates are loaded on the SEPHAROSE columns, the ends of the columns are closed, and the columns placed on a rotary shaker for 2 hours, at room temperature and 16 hours at 4°C. After the columns settle, they are washed with TX buffer. The fused proteins are eluted with 0.1 M carbonate/bicarbonate buffer, pH10. The eluate from each affinity column is concentrated by ultrafiltration using, for example, CENTRICON-30 cartridges. The final protein concentrate is resuspended in PBS buffer.

The individually purified fusion proteins are injected subcutaneously in Freund's adjuvant in rabbits. 1 mg of fused protein is injected at days 0 and 21, and rabbit serum is collected on days 42 and 56.

Control rabbits are similarly immunized with purified glutathione S-transferase (Sj26) protein obtained from control bacterial lysate and purified β -galactosidase obtained from commercial sources.

Minilysates are prepared (essentially as described above for the fusion proteins but omitting the affinity purification steps) from the following transformed bacterial cultures: (1) cells transformed with the CAP37/glutathione S-transferase fusion-encoding plasmid; (2) cells transformed with the glutathione S-transferase encoding plasmid; (3) cells transformed with each of the CAP37 peptide/ β -galactosidase fusion-encoding plasmids (Example 11); and, (4) cells transformed with the β -galactosidase fusion-encoding plasmid. The minilysates and purified CAP37 protein were fractionated by SDS-PAGE, and the bands

transferred to nitrocellulose filters for Western blotting (Ausubel et al.).

Serum from control (Sj26) rabbits is expected to be immunoreactive with each of the Sj26 and Sj26 fused protein antigens. Serum from the animal immunized with CAP37/Sj26 fused protein is expected to be reactive with Sj26, Sj26 fused protein antigen, and purified CAP37 indicating some specific immunoreaction with CAP37. The serum from the animal immunized with CAP37/Sj26 fused protein may also immunoreact with the CAP37 peptide/ β -galactosidase antigens, but is not expected to react with β -galactosidase antigen alone.

Serum from control (β -galactosidase) rabbits is expected to be immunoreactive with each of the β -galactosidase and β -galactosidase fused protein antigens. Serum from the animal immunized with CAP37/ β -galactosidase fused protein is expected to be reactive with β -galactosidase, β -galactosidase-fused protein antigen, and purified CAP37 indicating some specific immunoreaction with CAP37. The serum from the animal immunized with CAP37/ β -galactosidase fused protein may also immunoreact with the CAP37 peptide/Sj26 antigens, but is not expected to react with Sj26 antigen alone.

Although the invention has been described with reference to specific methods and compositions, it will be apparent to one skilled in the art how various modifications and applications of the methods may be made without departing from the invention.

[illegible]

Table 1

	1	10	20
CAP37	I-V-G-G-R-K-A-R-P-R-Q-F-P-F-L-A-S-I-Q-N-Q-G-R-H-F----		
ELAST	I-V-G-G-R-R-A-R-P-H-A-W-P-F-M-V-S-L-Q-L-R-G-G-H-F---		
FACTD	I-L-G-G-R-E-A-E-A-H-A-R-P-Y-M-A-S-V-Q-L-N-G-A-E-L----		
PLASM	I-V-G-G-C-V-S-K-P-H-S-W-P-W-Q-V-S-L-R-R-S-S-R-H-F----		
CATG	I-I-G-G-R-E-S-R-P-H-S-R-P-Y-M-A-Y-L-Q-I-Q-S-P-A-G-Q-		
RMCP1	I-I-G-G-V-E-S-R-P-H-S-R-P-Y-M-A-H-L-E-I-T-T-E-R-G-Y-		
RMCP11	I-I-G-G-V-E-S-I-P-H-S-R-P-Y-M-A-H-L-D-I-V-T-E-K-G-L-		
CCPI	I-I-G-G-H-E-V-K-P-H-S-R-P-Y-M-A-L-L-S-I-K-D-Q-Q-P-E-		
HF	I-I-G-G-D-T-V-V-P-H-S-R-P-Y-M-A-L-L-K-L-S-S-N-T-----		

CAP37	-----C-G-G-A-L-I-H-A-R-F-V-M-T-A-A-S-C-	42	
ELAST	-----C-G-A-T-L-I-A-P-N-F-V-M-S-A-A-H-C-	42	
FACTD	-----C-G-G-V-L-V-A-E-Q-W-V-L-T-A-A-H-C-	42	
PLASM	-----C-G-G-T-L-I-S-P-K-W-V-L-T-A-A-H-C-	42	
CATG	S-R---C-G-G-F-L-V-R-E-D-F-V-L-T-A-A-H-C-	45	
RMCP1	K-A-T-C-G-G-F-L-V-N-R-N-F-V-M-T-A-A-H-C-	46	
RMCP11	R-V-I-C-G-G-F-L-I-S-R-Q-F-V-L-T-A-A-H-C-	46	
CCPI	A---I-C-G-G-F-L-I-R-E-D-F-V-L-T-A-A-H-C-	45	
HF	----I-C-A-G-A-L-I-E-K-N-W-V-L-T-A-A-H-C-	42	

Table 2

81

CC

2

ATCTGTCTAGGGCCCCGGCTGCCAGGGCAGAACTCAGACTTAAAGCACAGAGAAG	57
GCAAGCCGGCTTGGCCCTGGGTCAACAGCCAGCCCCGGCCTGGACGATCCCCGGAAA	112
GGCCTCAGGGCGGACCGTGTGCGGGACTCAGGGGCCCCCCTGTCTCTTAGGGAG	168
TGGCAACG ATG GCG GAG GGT GGG TCC CCC CGC AGC CCC ACT GGG MET Gly Glu Gly Gly Ser Pro Arg Ser Pro Thr Gly -48 -37	211
TGG ATA GAG CTG AGG CTG CAG CTT CAC ACC CCC TCC CGG CCA Tyr Ile Glu Leu Arg Leu Gln Leu His Thr Pro Ser Arg Pro -23	253
CTG TGT GGA TTC TTG GGG ATC TCA GAG CTG TCT CCC CCC GAC Leu Cys Gly Phe Leu Gly Ile Ser Glu Leu Ser Pro Pro Asp -9	295
CCA GCG TCC AGC CCC CTT TTG GAC ATC GTT GGC GCG CGG AAG Pro Gly Ser Ser Pro Leu Leu Asp Ile Val Gly Gly Arg Lys 1 6	337
GCG AGG CCC CGC CAG TTC CCG TTC CTG GCC TCC ATT CAG AAT Ala Arg Pro Arg Gln Phe Pro Phe Leu Ala Ser Ile Gln Asn 20	379
CAA GCG AGG CAC TTC TGC GGG GGT GCC CTG ATC CAT GCC CGC Gln Gly Arg His Phe Cys Gly Gly Ala Leu Ile His Ala Arg 34	421
TTC CTG ATG ACC GCG GCC AGC TGC TTC CAA ACC CAG AAC CCC Phe Val MET Thr Ala Ala Ser Cys Phe Gln Ser Gln Asn Pro 48	463
GGG GTT AGC ACC GTG GTC CTG GGT GCC TAT GAC CTG AGG CGG Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu Arg Arg 62	505
CGG GAG AGG CAG TCC CGC CAG ACG TTT TCC ATC AGC AGC ATG Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser MET 76	547
AGC GAG AAT GCG TAC GAC CCC CAG CAG AAC CTG AAC GAC CTG Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu 90	589
ATG CTG CTT CAG AGG TTT GTC AAC GTG ACT GTG ACC CCC GAG MET Leu Leu Gln Arg Phe Val Asn Val Thr Val Thr Pro Glu 104	631
GAC CAG TGT CGC CCC AAC AAC GTG TGC ACC GGT GTG CTC ACC Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr 118	673
CGC CGC GGT GCG ATC TGC AAT GGG GAC GGG GCG ACC CCC CTC Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu 132	715
GTC TGC CAG GCG CTG GCC CAC GCG GTG GCC TCC TTT TCC CTG Val Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu 146	757
GGG CCC TGT GCG CGA GCG CCT GAC TTC TTC ACC CGA GTG GCG Gly Pro Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala 160	799
CTC TTC CGA GAC TGG ATC GAT GGT GTT CTC AAC AAC CCG GGA Leu Phe Arg Asp Tyr Ile Asp Gly Val Leu Asn Asn Pro Gly 174	841
CCG GCG CCA GCC TAG GGGGGCTGTGACCTCCCATGGAGCCCAAGCCCCCGC Pro Gly Pro Ala End 178	891
CCTCCACACCTCCGGCGCTCCGCACCCACCTCCCAAGGGCCCCCGCCCTGCCCCCG	946
TCCCGCCAGAGGGGCCCTGGCTGTAAATAAAGAACCGCATCTCTCTCTGAAA	998

Table 3

CCC	ATG	ACC	CGG	CTG	ACA	GTC	CTG	GCC	CTG	CTG	GCT	GGT	CTG	42
MET	Thr	Arg	Leu	Thr	Val	Leu	Ala	Leu	Leu	Ala	Gly	Leu		
-26													-14	
CTG	GCG	TCC	TCG	AGG	GCC	GGC	TCC	AGC	CCC	CTT	TTG	GAC	ATC	84
Leu	Ala	Ser	Ser	Arg	Ala	Gly	Ser	Ser	Pro	Leu	Leu	Asp	Ile	
													1	
GTT	GGC	GGC	CGG	AAG	GCG	AGG	CCC	CGC	CAG	TTC	CCG	TTC	CTG	126
Val	Gly	Gly	Arg	Lys	Ala	Arg	Pro	Arg	Gln	Phe	Pro	Phe	Leu	
													15	
GCC	TCC	ATT	CAG	AAT	CAA	GGC	AGG	CAC	TTC	TGC	GGG	GGT	GCC	168
Ala	Ser	Ile	Gln	Asn	Gln	Gly	Arg	His	Phe	Cys	Gly	Gly	Ala	
													29	
CTG	ATC	CAT	GCC	CGC	TTC	GTG	ATG	ACC	GCG	GCC	AGC	TGC	TTC	210
Leu	Ile	His	Ala	Arg	Phe	Val	MET	Thr	Ala	Ala	Ser	Cys	Phe	
													43	
CAA	AGC	CAG	AAC	CCC	GGG	GTT	AGC	ACC	GTG	GTG	CTG	GGT	GCC	252
Gln	Ser	Gln	Asn	Pro	Gly	Val	Ser	Thr	Val	Val	Leu	Gly	Ala	
													57	
TAT	GAC	CTG	AGG	CGG	CGG	GAG	AGG	CAG	TCC	CGC	CAG	ACG	TTT	294
Tyr	Asp	Leu	Arg	Arg	Arg	Glu	Arg	Gln	Ser	Arg	Gln	Thr	Phe	
													71	
TCC	ATC	AGC	AGC	ATG	AGC	GAG	AAT	GGC	TAC	GAC	CCC	CAG	CAG	336
Ser	Ile	Ser	Ser	MET	Ser	Glu	Asn	Gly	Tyr	Asp	Pro	Gln	Gln	
													85	
AAC	CTG	AAC	GAC	CTG	ATG	CTG	CTT	CAG	CTG	GAC	CGT	GAG	GCC	378
Asn	Leu	Asn	Asp	Leu	MET	Leu	Leu	Gln	Leu	Asp	Arg	Glu	Ala	
													99	
AAC	CTC	ACC	AGC	AGC	GTG	ACG	ATA	CTG	CCA	CTG	CCT	CTG	CAG	420
Asn	Leu	Thr	Ser	Ser	Val	Thr	Ile	Leu	Pro	Leu	Pro	Leu	Gln	
													113	
AAC	GCC	ACG	GTG	GAA	GCC	GGC	ACC	AGA	TGC	CAG	GTG	GCC	GGC	462
Asn	Ala	Thr	Val	Glu	Ala	Gly	Thr	Arg	Cys	Gln	Val	Ala	Gly	
													127	
TGG	GGG	AGC	CAG	CGC	ACT	GGG	GGG	CGT	CTC	TCC	CGT	TTT	CCC	504
Trp	Gly	Ser	Gln	Arg	Ser	Gly	Gly	Arg	Leu	Ser	Arg	Phe	Pro	
													141	
AGG	TTT	GTC	AAC	GTG	ACT	GTG	ACC	CCC	GAG	GAC	CAG	TGT	CGC	546
Arg	Phe	Val	Asn	Val	Thr	Val	Thr	Pro	Glu	Asp	Gln	Cys	Arg	
													155	
CCC	AAC	AAC	GTG	TGC	ACC	GGT	GTG	CTC	ACC	CGC	CGC	GGT	GCC	588
Pro	Asn	Asn	Val	Cys	Thr	Gly	Val	Leu	Thr	Arg	Arg	Gly	Gly	
													169	
ATC	TGC	AAT	GGG	GAC	GGG	GGC	ACC	CCC	CTC	GTG	TGC	GAG	GCC	630
Ile	Cys	Asn	Gly	Asp	Gly	Gly	Thr	Pro	Leu	Val	Cys	Glu	Gly	
													183	
CTG	GCC	CAC	GGC	GTG	GCC	TCC	TTT	TCC	CTG	GGG	CCC	TGT	GCC	672
Leu	Ala	His	Gly	Val	Ala	Ser	Phe	Ser	Leu	Gly	Pro	Cys	Gly	
													197	
CGA	GGC	CCT	GAC	TTC	TTC	ACC	CGA	GTG	GCG	CTC	TTC	CGA	GAC	714
Arg	Gly	Pro	Asp	Phe	Phe	Thr	Arg	Val	Ala	Leu	Phe	Arg	Asp	
													211	
TGG	ATC	GAT	GGT	GTT	CTC	AAC	AAC	CCG	GGA	CCG	GGG	CCA	GCC	756
Trp	Ile	Asp	Gly	Val	Leu	Asn	Asn	Pro	Gly	Pro	Gly	Pro	Ala	
													225	
TAG	GGGGG	CCTGTG	ACCTCCC	ATGG	AGCCC	AGCCCC	GGCCCTCC	CACACCT	CCGGC					810
End														
GCTCCG	CACCCACCT	CCCACGG	CCCCCGCCCC	CTGCC	CCCCGTC	CGGCC	CAGAGGG	GGCC						865
CTGGCTG	TAAATAA	GAAGCCG	ATCTCT	CCTCTG	AAAAAAA									905

Table 4

Peptide 1, F-Q-S-Q-N-P-G-V-S-T-V (Amino acids 43 - 53)

Peptide 2, S-I-S-S-M-S-E-N-G (Amino acids 72 - 80)

5 Peptide 3, S-Q-H-S-G-G-R-L-S-R-F-P-R-F (Amino acids
130 - 143)

10

Table 5

EFFECT OF PEPTIDE #1 ON MONOCYTE CHEMTAXIS

5		
	<u>chemoattractant conc</u>	<u>Distance migrated in μm</u>
	10^{-7}M peptide #1	57.2
	10^{-8}M peptide #1	51.5
10	10^{-9}M peptide #1	57.7
	10^{-10}M peptide #1	63.5
	10^{-11}M peptide #1	51.3
	10^{-12}M peptide #1	50.2
15	10^{-8}M FMLP	86.2
	10^{-9}M CAP37	78.4
20	Geys buffer	45.8

25

Table 6

EFFECT OF PEPTIDE #3 ON MONOCYTE CHEMOTAXIS

5	<u>chemoattractant conc</u>	<u>Distance migrated in μm</u>
	10^{-8}M peptide #3	46.5
	10^{-9}M peptide #3	52.0
	10^{-10}M peptide #3	66.6
	10^{-11}M peptide #3	52.8
10	10^{-12}M peptide #3	50.5
	10^{-13}M peptide #3	50.2
	10^{-8}M FMLP	91.4
15	10^{-9}M CAP37	73.6
	Geys buffer	43.9
20		

Table 7

IT IS CLAIMED:

1. A recombinant DNA molecule comprising a DNA sequence coding for a cationic granule protein, said protein comprising the sequence:

Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
10 Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
15 Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
20 Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro.

2. The DNA molecule of claim 1, which further encodes an amino terminal extension of said protein.

25

3. The DNA molecule of claim 2, where the amino terminal extension of said protein is as follows:
Met Thr Arg Leu Thr Val Leu Ala Leu Leu Ala Gly Leu Leu Ala
Ser Ser Arg Ala Gly Ser Ser Pro Leu Leu Asp.

30

4. The DNA molecule of claim 2, where the amino terminal extension of said protein is as follows:

Met.

- 35 5. The DNA molecule of claim 1, which further encodes a carboxy terminal extension of said protein.

6. The DNA molecule of claim 5, where the carboxy terminal extension of said protein is as follows:

Gly Pro Ala.

5 7. A recombinantly produced cationic granule protein comprising the sequence:

Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
10 Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
15 Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
20 Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro.

8. The protein of claim 7, which further comprises the
25 following amino terminal extension of said protein:

Met Thr Arg Leu Thr Val Leu Ala Leu Leu Ala Gly Leu Leu Ala
Ser Ser Arg Ala Gly Ser Ser Pro Leu Leu Asp.

9. The protein of claim 7, which further comprises the
30 following amino terminal extension of said protein:

Met.

10. The protein of claim 7, which further comprises
the following carboxy terminal extension of said protein:
35 Gly Pro Ala.

11. The protein of claim 7, which further includes, attached to the amino or the carboxy terminus of the sequence, a second protein coding sequence.

5 12. The protein of claim 11, wherein the second protein chosen from among the group consisting of ricin A chain, abrin A chain and trichosanthin.

10 13. The protein of claim 7, which is a chemoattractant for monocytes.

14. The protein of claim 7, which binds to bacterial lipopolysaccharide.

15 15. Peptides having at least 5 amino acids which are chemotactic for monocytes and are derived from the following sequence:

Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
20 Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
25 Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
30 Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro Gly Pro Ala.

16. Peptides having at least 5 amino acids which bind bacterial lipopolysaccharide and are derived from the following sequence:

5 Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
 Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
 Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
 Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
 Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
 10 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
 Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
 Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
 Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
 Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
 15 Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
 Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
 Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
 Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
 Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro Gly Pro Ala.
 20

17. A peptide of Claim 15 comprising at least the following amino acid sequence: -Phe-Gln-Ser-Gln-Asn-Pro-Gly-Val-Ser-Thr-Val-.

25 18. Peptides which are chemotactic for monocytes and which are comprised of at least the following amino acid sequence: -Ser-Gln-His-Ser-Gly-Gly-Arg-Leu-Ser-Arg-Phe-Pro-Arg-Phe-.

30 19. A process for obtaining a homogeneously pure, monocyte chemotactic protein from polymorphonuclear leukocytes having cell membranes, comprising the steps of:
 a) disrupting the cell membranes to release granules and other intracellular components;
 35 b) separating a granule fraction by density;

- c) making a crude granule extract from said granule fraction;
- d) binding said crude granule extract to a cation exchange matrix;
- 5 e) eluting said bound portion of said crude granule extract from said matrix to produce an eluate;
- f) concentrating said eluate;
- g) applying said concentrated eluate to a second matrix capable of separating proteins on the basis of molecular size;
- 10 h) collecting a second eluate from said second matrix;
- i) fractionating said second eluate by high performance liquid chromatography through a column to produce first and second protein fractions; and
- 15 j) collecting said second fraction containing the protein having monocyte chemotactic activity.

20 20. The process of Claim 19 wherein said column of said fractionating step comprises a matrix that promotes hydrophobic, nondenaturing interactions with proteins.

21. A recombinant process for the production of bioactive peptides comprising,

25 (a) an expression vector containing a DNA sequence encoding a peptide having at least 5 amino acids which are chemotactic for monocytes and are derived from the following sequence:

30 Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
35 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val

Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
5 Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro,

- and, said vector further containing
- 10 transcriptional and translational control elements
flanking said DNA sequence effective to express said
DNA coding sequence,
- said vector also containing a gene which
facilitates selection of the vector in a suitable host;
- 15 (b) introducing said expression vector into a suitable
host;
- and,
- (c) isolating the bioactive peptide expressed by the
vector.

- 20
22. The process of claim 21, where the expression
vector further includes a DNA sequence encoding a
collagenase cleavage site and the α -galactosidase protein,
resulting in an in-frame fusion between α -galactosidase
25 protein, the collagenase cleavage site, and the coding
sequence of the bioactive peptide.

23. The process of claim 22, where the fusion protein
is isolated by affinity chromatography for the α -
30 galactosidase protein portion of the fusion protein, and the
bioactive peptide is liberated from the fusion protein by
digestion of the fusion protein with the collagenase
proteinase.

24. An expression vector for introduction into a host cell comprising,

a DNA sequence encoding the following protein sequence:

5 Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
10 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
15 Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro,

20

and,

flanking said DNA sequence, transcriptional and translational control elements effective to express said DNA coding sequence,

25 said vector also containing a gene which facilitates selection of the vector in the host cell.

25. The expression vector of claim 24, where the transcriptional control elements include a promoter and a
30 poly-adenylation signal.

26. The expression vector of claim 25, where the promoter is obtained from cytomegalovirus and the polyadenylation signal is obtained from SV40.

35

27. The expression vector of claim 26, where the gene to facilitate selection is the dihydrofolate reductase gene.

28. A recombinant process for the production of a cationic granule protein comprising,
(a) an expression vector containing a DNA sequence encoding a protein that is comprised of the following amino acid sequence:

10 Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
15 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
20 Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro,

25 and, said vector further containing
transcriptional and translational control elements
flanking said DNA sequence effective to express said
DNA coding sequence,

said vector also containing a gene which
30 facilitates selection of the vector in a suitable host;

(b) introducing said expression vector into a suitable
host;

and,

(c) isolating the recombinant protein expressed by the
35 vector.

29. The process of claim 28, where the expression vector further includes a DNA sequence encoding a thrombin cleavage site and the glutathione-S-transferase protein (Sj26), resulting in an in-frame fusion between Sj26, the
5 thrombin cleavage site, and the coding sequence of the cationic granule protein.

30. The process of claim 29, where the fusion protein is isolated by affinity chromatography for the Sj26 protein
10 portion of the fusion protein, and the cationic granule protein is liberated from the fusion protein by digestion of the fusion protein with the thrombin proteinase.

31. The process of claim 28, wherein the host is
15 selected from the group consisting of: bacteria, yeast, and mammalian cells.

32. A method of treating a wound by the application of a topical medication comprising,
20 a cationic granule protein comprising the following sequence:

Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
25 Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
30 Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
35 Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg

Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro,
and, said protein present in the medication in a
pharmacologically effective amount to promote wound healing.

5 33. The method of claim 32, wherein said topical
medication further comprises epidermal growth factor in a
pharmacologically effective amount to promote wound healing.

10 34. The method of claim 32, wherein the form of the
topical medication is selected from the group consisting of:
pastes, gels, creams, and ointments.

15 35. A method for treating diseases involving monocyte
localization or defects of monocyte chemotaxis in an animal
comprising the step of administering to said animal, a
therapeutic composition comprising a pharmacologically
effective amount of a monocyte chemotactic protein
characterized by a molecular weight of 36,000 to 38,000
daltons as measured by SDS-PAGE, under reducing conditions.
20

36. The method of Claim 35, further comprising, a
pharmaceutically acceptable carrier.

25 37. A method for treating diseases in animals
involving monocyte localization or defects of monocyte
chemotaxis comprising the step of administering to said
animal, a therapeutic composition comprising a
pharmacologically effective amount of a peptide having at
least 5 amino acids derived from the following sequence:
30 Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
35 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val

Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
 Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
 Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
 Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
 5 Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
 Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
 Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
 Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro Gly Pro Ala.

10 38. A method for increasing the migration of monocytes
 to a particular tissue site in an animal, comprising the
 step of administering to said tissue site a therapeutic
 composition, comprising a pharmacologically effective amount
 of a monocyte chemotactic protein.

15

39. The method of Claim 38, wherein said monocyte
 chemotactic protein is characterized by a molecular weight
 of between 36,000 and 38,000 daltons as measured by SDS-
 PAGE, under reducing conditions.

20

40. The method of Claim 38, wherein said monocyte
 chemotactic protein is comprised of a peptide having at
 least 5 amino acids derived from the following sequence:

25 Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
 Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
 Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
 Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
 Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
 30 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
 Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
 Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
 Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
 Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
 35 Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
 Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val

Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
 Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
 Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro Gly Pro Ala.

- 5 41. A hybrid protein comprising the cationic granule protein having the following sequence:

Ile Val Gly Gly Arg Lys Ala Arg Pro Arg Gln Phe Pro Phe Leu
 Ala Ser Ile Gln Asn Gln Gly Arg His Phe Cys Gly Gly Ala Leu
 10 Ile His Ala Arg Phe Val Met Thr Ala Ala Ser Cys Phe Gln Ser
 Gln Asn Pro Gly Val Ser Thr Val Val Leu Gly Ala Tyr Asp Leu
 Arg Arg Arg Glu Arg Gln Ser Arg Gln Thr Phe Ser Ile Ser Ser
 Met Ser Glu Asn Gly Tyr Asp Pro Gln Gln Asn Leu Asn Asp Leu
 Met Leu Leu Gln Leu Asp Arg Glu Ala Asn Leu Thr Ser Ser Val
 15 Thr Ile Leu Pro Leu Pro Leu Gln Asn Ala Thr Val Glu Ala Gly
 Thr Arg Cys Gln Val Ala Gly Trp Gly Ser Gln Arg Ser Gly Gly
 Arg Leu Ser Arg Phe Pro Arg Phe Val Asn Val Thr Val Thr Pro
 Glu Asp Gln Cys Arg Pro Asn Asn Val Cys Thr Gly Val Leu Thr
 Arg Arg Gly Gly Ile Cys Asn Gly Asp Gly Gly Thr Pro Leu Val
 20 Cys Glu Gly Leu Ala His Gly Val Ala Ser Phe Ser Leu Gly Pro
 Cys Gly Arg Gly Pro Asp Phe Phe Thr Arg Val Ala Leu Phe Arg
 Asp Trp Ile Asp Gly Val Leu Asn Asn Pro Gly Pro,

where said cationic protein is covalently linked to a second protein.

25

42. The hybrid protein of claim 41, wherein the second protein is an antibody.

43. The hybrid protein of claim 41, wherein the second
 30 protein is chosen from among the group consisting of ricin A chain, abrin A chain, and trichosanthin.

44. A homogeneously pure monocyte chemotactic protein.

35

45. The chemotactic protein of Claim 44, wherein said protein is purified from polymorphonuclear leukocytes, is devoid of other contaminating granule proteins including the defensins, cathepsin G, myeloperoxidase, lactoferrin, and CAP 57, and further, wherein said protein has a molecular weight as determined by SDS-PAGE, under reducing conditions, between 36,000 and 38,000 daltons.

46. The chemotactic protein of Claim 44, wherein said protein is devoid of contaminating granule proteins including the defensins, cathepsin G, myeloperoxidase, lactoferrin, and CAP57.

47. The chemotactic protein of Claim 46, wherein said protein has a molecular weight, as determined by SDS-PAGE, under reducing conditions, between 36,000 and 38,000 daltons.

48. The chemotactic protein of Claim 44, wherein said protein has a molecular weight, as determined by SDS-PAGE, under reducing conditions, between 36,000 and 38,000 daltons.

49. The chemotactic protein of Claim 46, wherein said protein has an amino terminal amino acid sequence comprising the following amino acids:

```

5      5      10      15
Ile-Val-Gly-Gly-Arg-Lys-Ala-Arg-Pro-Arg-Gln-Phe-Pro-Phe-Leu-
Ala-

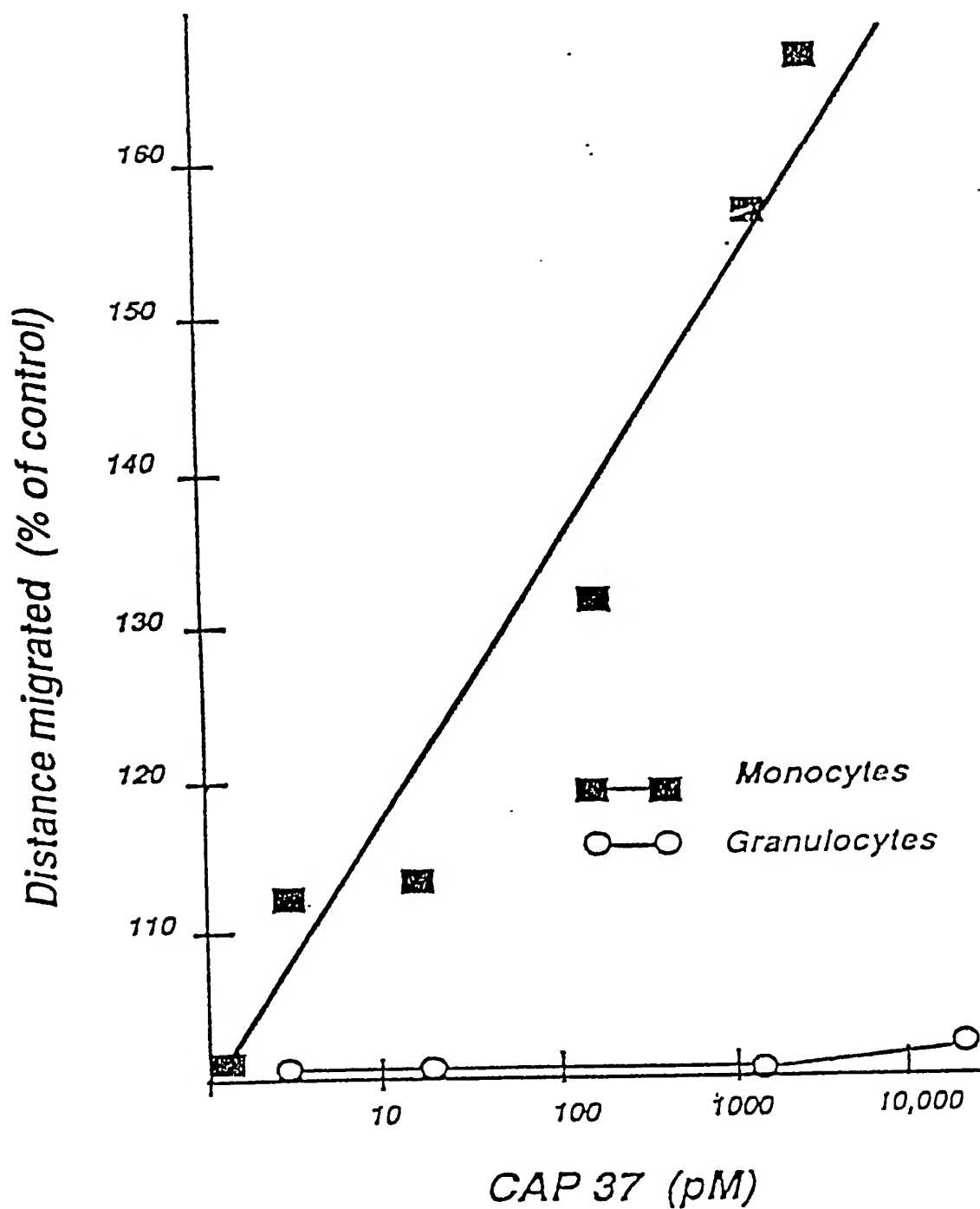
      20      25      30
10    Ser-Ile-Gln-Asn-Gln-Gly-Arg-His-Phe-Cys-Gly-Gly-Ala-Leu-

      35      40      45
Ile-His-Ala-Arg-Phe-Val-Met-Thr-Ala-Ala-Ser-Cys-Phe-Gln-Ser-
Gln-

15    Asn-

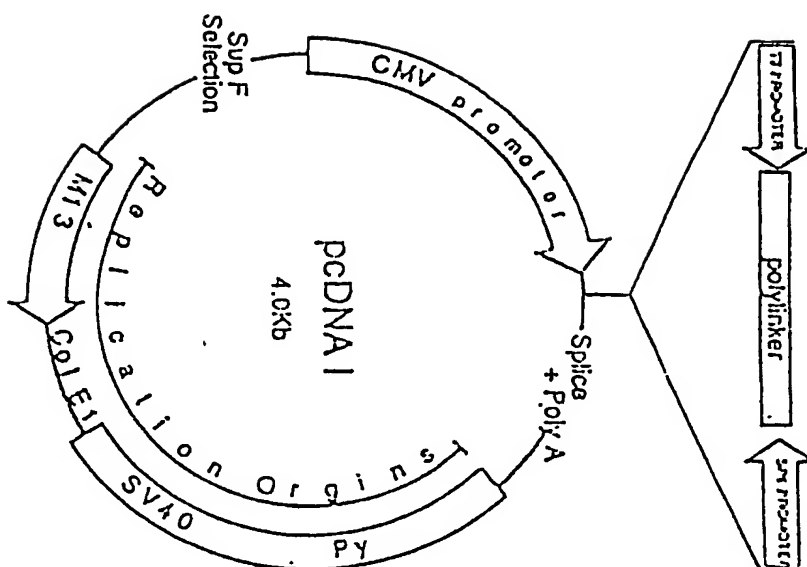
```

CAP 37- A SPECIFIC MONOCYTE CHEMOTAXIN



BEST AVAILABLE COPY

FIG.1

[illegible]

BEST AVAILABLE COPY

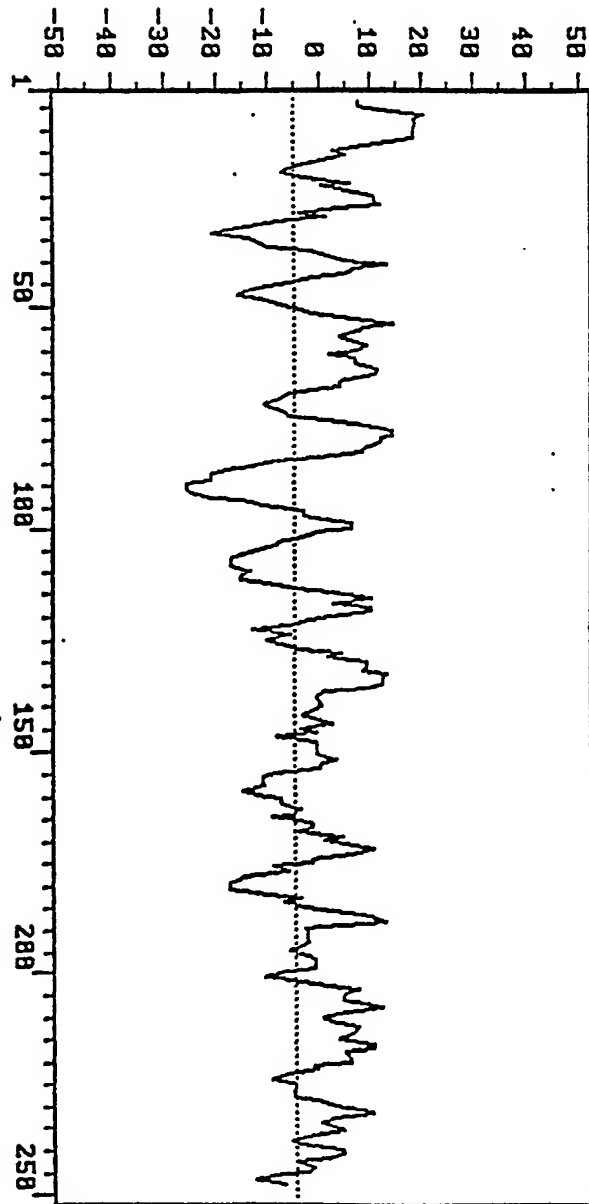


FIG. 3

BEST AVAILABLE COPY

4/5 BEST AVAILABLE COPY

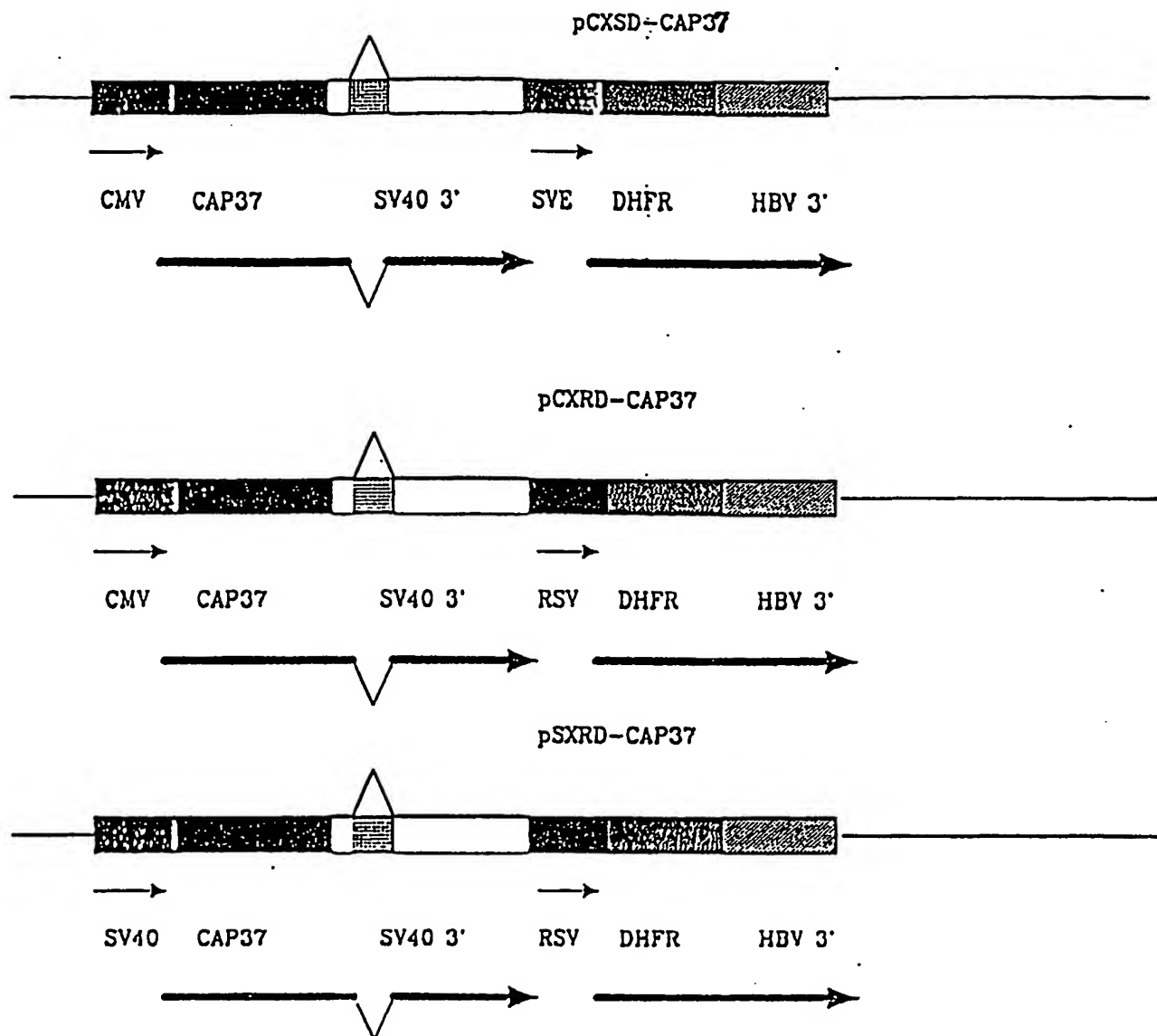


FIG. 4

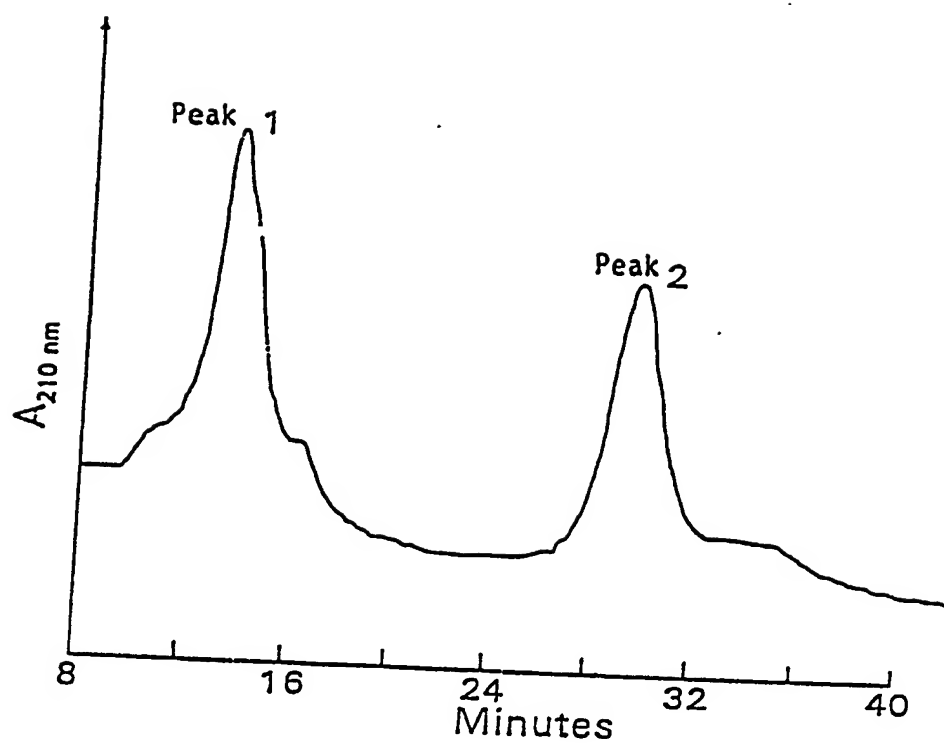


FIG. 5

BEST AVAILABLE COPY

INTERNATIONAL SEARCH REPORT

International Application No PCT/US902/03772

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 3

According to International Patent Classification (IPC) or to both National Classification and IPC
 IPC(5): C12N 15/09, 15/11, 15/19, 15/63; C07K 3/18, 3/22, 3/28, 7/06, 7/08, 7/10, 7/40, 15/02, 15/26
 U.S.Cl: 530/351, 415, 416, 417, 300, 402, 427, 330, 327; 514/17, 21; 435/172.3, 320; 536/27

II. FIELDS SEARCHED

Minimum Documentation Searched 4

Classification System 1

Classification Symbols

U.S.Cl. 530/351, 415, 416, 417, 427, 330; 514/17, 21; 435/172.3, 320; 536/27
 530/402, 327, 300

Documentation Searched other than Minimum Documentation
 to the Extent that such Documents are Included in the Fields Searched 5

SEARCHED US PAT AND DIALOG FILES 5, 35, 72, 340, 350, 351, 357 and 399
 and SEQUENCES IN PIR, SWISS PROT, EMBL. SEARCHED FOR CHEMOTACTIC
 ACTIVITY WITH MW OR MONOCYTE AND METHODS.

III. DOCUMENTS CONSIDERED TO BE RELEVANT 14

Category 6	Citation of Document, 14 with indication, where appropriate, of the relevant passages 17	Relevant to Claim No. 15
<u>N</u> <u>Y</u> <u>A</u>	Infection and Immunity, Vol. 53, No. 3, issued September 1986, (Shafer et al.), "Late Intraphagosomal Hydrogen Ion Concentration Favors the In Vitro Antimicrobial Capacity of a 37-Kilodalton Cationic Granule Protein of Human Neutrophil Granulocytes", pages 651-655. See pages 651-653.	<u>7, 9, 44-49</u> <u>1-6, 8, 10-18, 21-31</u> 19, 20
<u>N</u> , <u>P</u>	The Journal of Clinical Investigation, Vol. 95, issued May 1990, (Pereira et al.), "CAP37, a Human Neutrophil-Derived Chemotactic Factor with Monocyte Specific Activity", see pages 1468-1476.	<u>7, 9, 44-49</u> <u>1-6, 8, 10-30</u>
<u>N</u> <u>Y</u>	Cellular Immunology, Vol. 26, No. 2, issued 1976, (Leonard et al.), "Characterization of Mouse Lymphocyte Derived Chemo Tactic Factor", Abstract, BIOSIS No. 63020997, see pages 200-210.	<u>7, 44-49</u> <u>7, 9, 44-49</u>

* Special categories of cited documents: 16

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
- "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "A" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search 4

25 September 1990

International Searching Authority 1

ISA/US

Date of Mailing of this International Search Report 3

06 DEC 1990

Signature of Authorized Officer 10

Keith C. Furman
 Keith C. Furman

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

Category *	Citation of Document, with indication, where appropriate, of the relevant passages **	Relevant to Claim No 1*
Y	Gene, Vol. 67, issued 1988, (Smith et al.), "Single-Step Purification of Polypeptides Expressed in Escherichia Coli as Fusions with Glutathione S-Transferase", pages 31-40. See pages 31 and 38.	28-31
Y	US, A, 4,543,329 (Daum et al.), 24 September 1985, see the abstract, column 1 and column 9.	10,21-24
Y	The Journal of Biological Chemistry, Vol.263, Vol. 15, issued May 1988, (Hanada et al.) "Purification and Reconstitution of Escherichia coli Proline Carrier Using a Site Specifically Cleavable Fusion Protein", pages 7181-7185. See pages 7181 and 7182.	10,21-24
A,P	Chemical Abstracts No. 111:34668z, Published 1990, (Tsmo et al.), "An Episomal Vector for the Expression of Selected DNA Fragments Coding for Polypeptides in Mammalian Cells and Methods for the Production Thereof", European Patent Application EP 292,879, 30 November 1988.	24-27
Y	Chemical Abstracts No. 110:207240p, Published 1989, Piatak et al. "Recombinant Ricin B Muteins and Their use in the Preparation of Conjugates of Ricin muteins with Binding Proteins Such as Antibodies", PCT International Application WO 88 07,081, 22 September 1988. See abstract	11,12,41-43
Y,P	US, A, 4,912,111 (Sank et al.), 27 March 1990, see columns 3 and 4.	32-34
Y	Abstract, WPI Accession No 86-046523/07 of JP 61001616 (Teijin), 07 January 1986. "Monocyte Chemotactic factor has activity for human blood monocyte". See abstract.	44

FURTHER INFORMATION CONTINUED FROM THE SECOND SHEET

X Y	Abstract, BIOSIS No. 88054394 of The International Journal of Biochemistry, Vol. 21, No. 4, Published 1989, "Further Studies on a Chemoattractant Derived from Aleurites-Forddi Hemsl. Seed", (Schichigo et al.), pages 433-438.	7,44-49 7,9,44-49
Y	Gene, Vol. 62, issued 1988, (Scholtissek et al.) "A Plasmid Vector System for the Expression of a Triprotein Consisting of beta-Galactosidase, a Collagenase Recognition Site and a Foreign Gene Product", pages 55-64. See pages 55, 58, 63 and 64.	10,21-24

V. ☐ OBSERVATIONS WHERE CERTAIN CLAIMS WERE FOUND UNSEARCHABLE¹

This international search report has not been established in respect of certain claims under Article 17(2) (a) for the following reasons:

1. ☐ Claim numbers _____, because they relate to subject matter not required to be searched by this Authority namely:
2. ☐ Claim numbers _____, because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out¹, specifically:
3. ☐ Claim numbers _____, because they are dependent claims not drafted in accordance with the second and third sentences of PCT Rule 8.4(a).

VI. ☒ OBSERVATIONS WHERE UNITY OF INVENTION IS LACKING²

This International Searching Authority found multiple inventions in this international application as follows:

SEE ATTACHED SHEET

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims of the international application.
2. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims of the international application for which fees were paid, specifically claims:
3. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claim numbers:
4. ☐ As all searchable claims could be searched without effort justifying an additional fee, the International Searching Authority does not invite payment of any additional fee.

Remark on Protest

- ☒ The additional search fees were accompanied by applicant's protest.
☐ No protest accompanied the payment of additional search fees.

Specifically, the inventions are as follows:

I. Claims 1-4, 5, 6 and 21-23 drawn to a first invention comprising first product (DNA molecules) and first method of using (the recombinant processes of using the DNA molecules)- NOTE- claims 5 and 6 are a first specie of the generic molecule,

II. Claims 7-14 and 41-43 which are drawn to a second invention comprising a second product (a specific cationic granule proptein),

III. Claims 15-17 which are drawn to a third invention comprising a third product (a specific peptide fragment),

IV. Claim 18 which is drawn to a fourth invention comprising a fourth product (specific peptide fragment of 14 amino acids),

V. Claims 19 and 20 drawn to a fifth invention comprising a second process (method of purifying proteins in general),

VI. Claims 24-27 drawn to a sixth invention comprising a fifth product (an expression vector),

VII. Claims 28-31 drawn to seventh invention comprising a third process (method of recombinantly producing a specific protein),

VIII. Claims 32-34 drawn to an eighth invention comprising a fourth process (method of treating a wound with a specific protein),

IX. Claims 35,36, and 38-40 drawn to a ninth invention comprising a fifth process (method of treating a disease with a specific protein),

X. Claim 37 drawn to a tenth invention comprising a sixth process (method of treating a disease with a specific peptide), and

XI. Claims 44-49 drawn to an eleventh invention comprising a sixth product (homogenously pure chemotactic protein).

The fee for searching of ten additional inventions is \$1,500; however, the searchable claims of Group VII could be searched without effort justifying an additional fee (when the claims of Group II are searched). Therefore, the claims of Group VII can be grouped with those of Group II for the purposes of this requirement.

BEST AVAILABLE COP